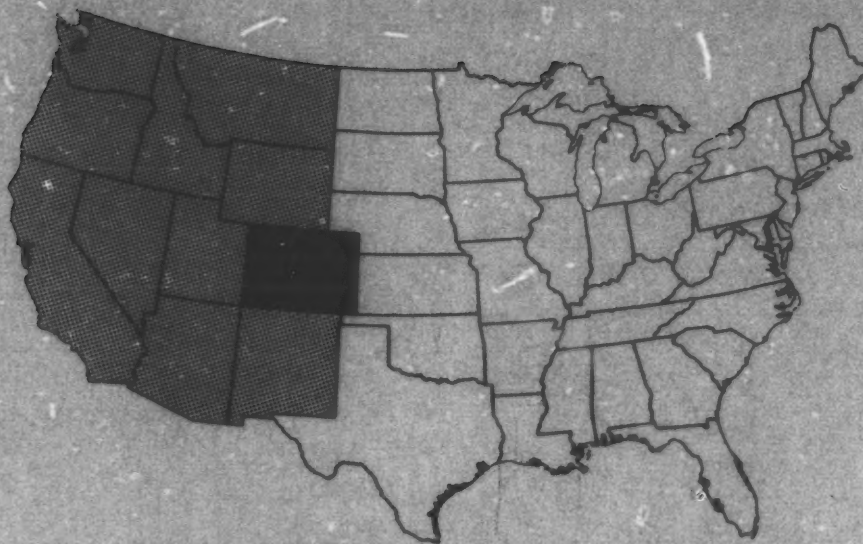


Special Publication

COLORADO



Availability of Federal Land for Mineral Exploration and Development in Western States: Colorado, 1984



UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

BUREAU OF MINES 75TH ANNIVERSARY

Special Publication

Availability of Federal Land for Mineral Exploration and Development in Western States: Colorado, 1984

By Richard A. Beach, Arthur W. Gray, Eileen K. Peterson,
and Clark A. Roberts

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UNITED STATES DEPARTMENT OF THE INTERIOR

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As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environment and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

Library of Congress Cataloging in Publication Data

Availability of federal land for mineral exploration and development in western states. Colorado, 1984.

(Bureau of Mines special report; 1985)

Bibliography: p. 20

Supt. of Docs. no.: I28.2.L22/3

1. Colorado—Public lands. 2. Mines and mineral resources—Colorado. 3. Mineral industries—Colorado. 4. Mineral lands—Colorado. I. Beach, Richard A. (Richard Allan), 1943- . II. United States. Bureau of Mines. III. Series.

HD243.C6A93 1985

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85-600177

AVAILABILITY OF FEDERAL LAND FOR MINERAL EXPLORATION AND DEVELOPMENT IN WESTERN STATES, 1984

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ABBREVIATIONS USED IN THIS REPORT

Units of Measure

bbl	barrel	Mcf	thousand cubic feet
ft	foot	mi ²	square mile
ft ³	cubic foot	mt	metric ton
gal	gallon	st	short ton
lb	pound	tr oz	troy ounce

Acronyms

ACEC	Area of critical environmental concern
BIA	Bureau of Indian Affairs, U.S. Department of the Interior
BLM	Bureau of Land Management, U.S. Department of the Interior
BOR	Bureau of Reclamation, U.S. Department of the Interior
CFR	Code of Federal Regulations
CGS	Colorado Geological Survey
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOI	U.S. Department of the Interior
FLPMA	Federal Land Policy and Management Act of 1976
FS	Forest Service, U.S. Department of Agriculture
FWS	Fish and Wildlife Service, U.S. Department of the Interior
KGS	Known geologic structure
KRCRA	Known recoverable coal resource area
MILS	Mineral Industry Location System, Bureau of Mines
NFS	National Forest System
NPS	National Park Service, U.S. Department of the Interior
NRA	National recreation area
NURE	National Uranium Resource Evaluation
NWPS	National Wilderness Preservation System
OPEC	Organization of Petroleum Exporting Countries
PLO	Public Land Order
RARE	Roadless Area Review and Evaluation
RMP/EIS	Resource management plan and environmental impact statement
SMCRA	Surface Mining Control and Reclamation Act of 1977
USGS	U.S. Geological Survey, Department of the Interior
WSA	Wilderness study area

By Richard A. Beach,¹ Arthur W. Gray,¹ Eileen K. Peterson,¹
and Clark A. Roberts¹

ABSTRACT

The Bureau of Mines inventoried and classified Federal land in Colorado to show its availability for mineral exploration and development, determined areas of the State that are favorable for deposits of certain minerals, and compared Federal land availability with mineral favorability to demonstrate the extent of restricted Federal land in favorable areas.

Colorado has 24.7 million acres of Federal land (37.2% of the State). About 5.22 million acres of Federal land is favorable for selected metallic and nonmetallic minerals, of which 78.3% is available and 21.7% is unavailable or severely restricted. About 2.63 million acres is favorable for uranium (and partly for vanadium); 72.4% is available and 27.6% is unavailable or severely restricted. About 7.02 million acres is favorable for and 9.90 million acres more is permissible for (capable of containing) oil and gas; 73.9% is available and 26.1% is unavailable or severely restricted. About 6.31 million acres is favorable for coal, 1.02 million acres for oil shale, and 0.25 million acres for the aluminum minerals alunite and dawsonite; as of July 1, 1984, all Federal land not already leased for these minerals is unavailable. Part of the available Federal land is subject to less stringent restrictions.

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INTRODUCTION

Federal land,² which composes about one-third of the United States, is a vast and rich store of natural resources and an important source of mineral raw materials for the Nation.

So that Federal land and the diverse array of resources associated with it are managed in the public interest, numerous laws, regulations, and policies have been developed to protect selected resource values and to foster or allow for the use of others. As a result, certain Federal lands have been set aside formally or are managed informally for specific purposes that may restrict use of the land for other purposes, such as mineral exploration and development. These restrictions, and especially their cumulative effect, may seriously impair our Nation's mineral supply.

OBJECTIVE

The Bureau of Mines' mission is to help ensure that the United States has an adequate and dependable supply of minerals to meet its defense and economic needs at acceptable social, environmental, energy, and economic costs. To help fulfill this mission, the Bureau is conducting a program for the 11 Western States that geographically compares Federal land availability for mineral exploration and development with mineral favorability, on a State-by-State basis.³ (The Bureau has a similar program for Alaska that will determine Federal and State land available for mineral exploration and development through six regional studies.) The resulting reports include 1:500,000-scale maps that show mineral favorability superimposed on Federal land status, allowing the reader to determine readily the extent to which the two designations coincide. This report describes the results of the Colorado State study.

The studies should be of special interest to policy makers who are concerned about domestic mineral supply and who chart future uses of Federal land. They also should be useful to those who manage this land, to other Federal, State, and local officials, and to the interested public.

PREVIOUS STUDIES

No study of Federal land can ignore the group of reports prepared for the Public Land Law Review Commission, created by the U.S. Congress in 1964, or the report of the commission itself, "One Third of the Nation's Land" (28),⁴ issued in 1970. Recognizing a growing demand for Federal land and resources, the commission advocated comprehensive land use planning to ensure that this land and its resources would be managed for the maximum benefit of the general public.

In 1975, a report by Bennethum and Lee (3) focused attention on the amount of Federal land that had become unavailable or restricted to mineral exploration and development. Although that study was not a refined assess-

ment, the conclusions—that about two-thirds of the Federal land in the United States was closed or restricted to mineral activities—were widely discussed. The implication that this situation could adversely affect U.S. mineral posture was heightened by the Organization of Petroleum Exporting Countries (OPEC) oil embargo and other events that emphasized the Nation's dependence upon foreign sources for many of the raw materials it requires. A subsequent report by the U.S. Department of the Interior (DOI) Task Force on Mineral Lands Availability (46) discussed the situation in greater detail, but neither report addressed the geographic relationship between the restricted Federal lands and areas of mineral favorability.

This relationship remained largely ignored in later studies that further discussed the issue of Federal land availability. The U.S. Congress Office of Technology Assessment prepared a comprehensive report about the management of fuel and nonfuel minerals on Federal land (45), and the U.S. General Accounting Office issued two reports: one about onshore oil and gas leasing (7) and the other on DOI's withdrawal review program (8) aimed at reducing unneeded restrictions on Federal land.

SCOPE AND METHOD

The report is comprised of three parts: (1) an inventory of Federal land ownership and availability status in Colorado, (2) an assessment of mineral favorability in the State, and (3) a comparison of Federal land availability with mineral favorability.

Inventory of Federal Land Ownership and Availability

Ownership and availability status for mineral exploration and development were determined for land in Colorado where the Federal Government owns the surface.

Most data on Federal land ownership in Colorado were obtained from U.S. Bureau of Land Management (BLM) surface-minerals management maps. Acreages were taken from U.S. General Services Administration data as reported in BLM's "Public Land Statistics 1983" (38), unless revised figures from a particular agency were obtained. On the basis of management responsibilities, Federal lands were placed in three groups: U.S. Forest Service (FS) land, BLM land, and other Federal agency land.⁵

Information about the availability of Federal land for mineral exploration and development was obtained from the BLM "Colorado Withdrawal Review Inventory" (39), FS management planning documents for individual national forests and grasslands (47) and planning documents for some BLM resource areas (43), a BLM inventory of "de facto" withdrawals (40), and a canvass of the other Federal agencies. Federal land was placed in categories of availability according to the degree of and authority for restrictions on it. The restrictions were categorized by (1) whether they result from formal legal action or informal management decision and (2) degree of availability, depending on

²This and other terms used in the report that may not be familiar to all readers are defined in the glossary (appendix A).

³The study for the State of Washington is available (Washington Division of Geology and Earth Resources. Geol. Map GM-30, 1984), and studies for Arizona, Nevada, New Mexico, and Oregon are under way.

⁴Italicized numbers in parentheses refer to items in the list of references preceding the appendixes at the end of this report.

⁵In this report, FS land means National Forest System (NFS) land managed by FS, BLM land means public land managed by BLM, and other Federal agency land means Federal land administered by a Federal agency other than FS or BLM.

how they may affect mineral exploration and development. Land was classified as available, slightly to moderately restricted, or unavailable or severely restricted. Detailed information about these categories and the types of restrictions in each is given later in the text and in appendix B.

The study does not include a substantial acreage of non-Federal land in which the Federal Government has part or all of the mineral interest. Neither Indian lands held in trust, which are discussed in appendix C, nor lands leased to or easements held by the Federal Government are included. Likewise, non-Federal restrictions on mineral exploration and development are not included. Owing to the number and variety of sources of data for this study, there is no exact cutoff date for Federal land status; however, the most recent data available were used. Although this is a detailed inventory, some data shown on the plates are generalized because of the small map scale (1:500,000); complete acreage data are included in the tables. Readers should consult BLM public land records for ownership status and local agency land managers for availability status of particular tracts of land.

Assessment of Mineral Favorability

Favorable areas for mineral deposits were identified, and five plates (maps) were prepared to show these areas for the important locatable and leasable minerals in Colorado. These include (1) selected metallic and nonmetallic minerals, (2) uranium and vanadium, (3) coal, (4) oil and gas, and (5) oil shale and the aluminum minerals alunite and dawsonite. Construction minerals and salable mineral materials were not assessed because they generally are more widely distributed and are less affected by Federal land restrictions. Sources of information included mineral-resource and mining district maps, the Bureau's Mineral Industry Location System (MILS), geologic maps, and input from the mineral industry. Criteria applied to rate the favorability of the State for particular minerals included production and occurrence data, geologic environment,

previous field assessment data where available, and professional judgment. Draft copies of the favorability maps were reviewed by the Colorado Geological Survey (CGS) and the U.S. Geological Survey (USGS). Favorable areas were then plotted on 1:500,000-scale maps for comparison with Federal land ownership and availability data.

The maps show areas of greater and lesser likelihood of the occurrence of mineral deposits. Because such deposits usually are hidden, the selection of favorable areas is a subjective process. Readers should recognize that no one can predict the location of undiscovered mineral deposits with certainty. Much of the area rated favorable probably does not contain valuable mineral deposits; conversely, such deposits may occur outside these areas.

Comparison of Federal Land Availability With Mineral Favorability

Geographic distribution of Federal land—available and unavailable or severely restricted—and areas favorable for mineral deposits were compared to determine the availability of Federal land in areas favorable for the occurrence of mineral deposits. Restrictions that apply to locatable minerals were compared with favorability for the selected metallic and nonmetallic minerals and for uranium and vanadium; restrictions that apply to oil and gas leasing were compared with favorability for oil and gas, coal, and oil shale and the aluminum minerals alunite and dawsonite. In general, Federal land in the favorable areas was measured by planimeter on a digitizing table or was determined from BLM surface-minerals management maps, to obtain the acreage of overlap among the various categories of availability and favorability. The relationship between mineral favorability and Federal land availability is shown on the plates, and the amount (acreage) of overlap, which is the basis for the conclusions of the study, is listed in tables. Neither the shape of the favorable areas nor the Federal land ownership and availability status should be regarded as fixed or exact; both are subject to change.

ACKNOWLEDGMENTS

The Bureau of Mines is grateful for assistance from many people in BLM, FS, USGS, CGS, and the mineral industry, who provided information and advice for this study. Specifically, the authors thank D. Chelius, withdrawal review coordinator, K. Purvis, land law examiner, J. Sorenson, cartographic technician, and especially A. Senti, realty specialist, of the BLM Colorado State Office, Denver, CO, who provided maps and other data about formal land withdrawals, and H. McBroom, R. Coker, C. Lance, and S. Collins, Branch of Energy and Minerals in the same office, who furnished studies of BLM mineral assessments, reviewed the mineral favorability maps, and made data available about restrictions to oil and gas leasing on BLM land. J. Dersch and F. Mullin, geologists, and J. Welch, in

the FS Region 2 office, Lakewood, CO, supplied draft mineral favorability maps of the national forests and grasslands as well as data about forest land status. A. Hornbaker, chief, Minerals Section, D. Collins, geologist, Minerals Section, and A. Scanlon, geologist, Mineral Fuels Section, CGS, Denver, CO, and C. Spencer, Branch of Oil and Gas Resources, and R. Taylor, deputy chief, Office of Mineral Resources, USGS, Lakewood, CO, reviewed the mineral favorability maps and provided helpful comments. J. Wells, president, Minerals Exploration Coalition, Lakewood, CO, and affiliated companies, including Anaconda Minerals Co., Freeport Exploration Co., and Gold Fields Mining Corp., provided data for the mineral favorability maps.

FEDERAL LAND OWNERSHIP AND AVAILABILITY

When the United States acquired the land that is now the State of Colorado through the Louisiana Purchase in 1803 and the Mexican Cession of 1848, all land, except Spanish land grants, became Federal lands. After the purchase of Alaska in 1867, the emphasis in public land management shifted from acquisition to disposal. Federal land in Colorado, usually sections 16 and 36 of each township, plus quantity grants, passed to the State under its 1875 Statehood Act for use to support schools and for other purposes. Other Federal land was sold to homesteaders and military veterans, granted to railroad corporations, and disposed of by a variety of sales or entries under the public land laws, including the mining laws. The Federal Government, however, retained a considerable amount of land. Recently, Federal land management has emphasized retention and limited acquisition, coupled with more intensive management for multiple or single public purposes.

Colorado, the eighth largest state in the Nation, contains 66.5 million acres. The classes of land and acreage are as follows:

Owned by Federal Government	24,739,000
Owned by State and local governments	3,582,000
Private land	37,262,000
Indian land	903,000
Total	66,486,000

About 24.7 million acres, or 37.2% (fig. 1) of Colorado is Federal land.* FS and BLM manage about 60.2% and 33.7%, respectively, of the Federal land in the State. The remaining Federal land (6.1%) is managed by other agencies (table 1).

*In addition, the Federal Government owns all or part of the minerals, but not the surface, under about 5.87 million acres (38, table 13); these severed Federal minerals were not included in this study. A much smaller acreage (about 364,000 acres) of Federal land (surface) is covered from mineral estates owned by others.

Table 1.—Federally owned land in Colorado, by agency, acres

Department of Agriculture:	
Forest Service	14,094,547
Agricultural Research Service	14,706
Subtotal	14,009,253
Department of the Interior:	
Bureau of Land Management	8,246,472
National Park Service	887,622
Bureau of Reclamation	342,602
Fish and Wildlife Service	58,929
Bureau of Indian Affairs	317
Subtotal	9,246,942
Department of Defense:	
Department of the Army	423,407
Army Corps of Engineers	36,280
Department of the Air Force	29,426
Subtotal	489,113
Department of Energy:	
Naval Oil Shale Reserves	54,993
Energy Research and Development Administration (no longer an independent agency)	29,364
Western Area Power Administration	446
Subtotal	84,803
Others¹	7,274
Total	24,739,085

¹Includes Department of Commerce (National Oceanic and Atmospheric Administration, National Bureau of Standards, and Office of Telecommunications (now National Telecommunications and Information Administration)), Department of Justice (Bureau of Prisons), Department of Transportation (Federal Aviation Administration), Department of the Treasury (Bureau of the Mint), General Services Administration, National Science Foundation, United States Postal Service, and Veterans Administration.

Source: Acreage supplied by individual agencies or taken from BLM's "Public Land Statistics 1983" (39).

Most of the Federal land is in the plateau region in the western part and in the mountainous region of central Colorado. FS land is concentrated in the mountainous region, whereas BLM land is predominant in the western part of the State. On the accompanying plates, Federal land is shown in three groups: FS land, BLM land, and other Federal land.

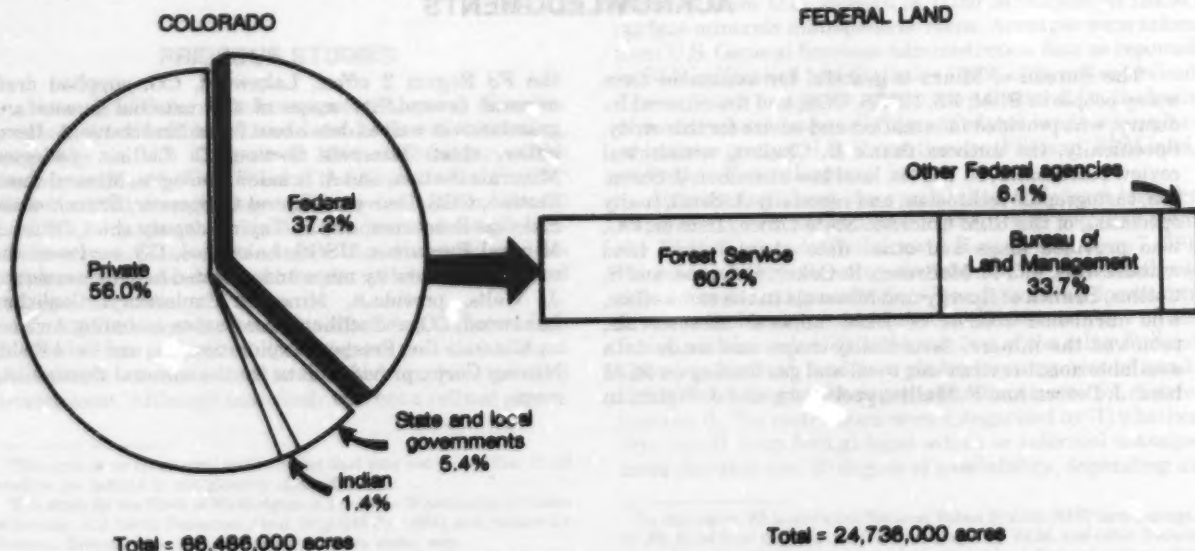


Figure 1.—Land ownership in Colorado.

Non-Federal lands comprise 62.8% of the State, including 1.4% that is Indian trust land. Although Indian land is held in trust by the Federal Government, it is not considered as Federal land in this study. Availability of Indian land, located in southwestern Colorado, is discussed in appendix C. Land owned by the State of Colorado is widely distributed throughout the State (33), as are the small parcels owned by local governments (counties and municipalities). Privately owned land occupies most of the plains region east of the mountains and part of the plateau region in the western part of the State. Some privately owned land is located in the large intermontane parks, along mountain drainages, and intermixed with FS and BLM lands.

APPLICABLE FEDERAL LAWS, REGULATIONS, AND POLICIES

Federal laws, regulations, and policies that govern (1) minerals and (2) Federal land management largely determine the availability of Federal land for mineral exploration and development. A list of the major laws is given in appendix D. Applicable Federal regulations and policies that provide additional direction for particular agencies are discussed in the text and in appendix E.

Minerals

Rights to minerals on Federal land are obtained by location, lease, or sale, depending upon the mineral and the type of Federal land involved. Most minerals on the public domain lands may be obtained by mining claim location under the General Mining Law of 1872, as amended. Locatable minerals include most metallic minerals and many nonmetallic minerals having special value in and of themselves. These minerals may be claimed anywhere on the public domain unless the land has been specifically withdrawn or segregated from entry under the General Mining Laws. Although the Federal Government has no authority concerning where locatable minerals are claimed on Federal land that is open for location, the land managing agencies do exercise some control over subsequent exploration and development activity under existing Federal regulations.

Some minerals are available by lease under the Mineral Leasing Act of 1920, as amended, and other mineral leasing laws. Leasable minerals of importance in Colorado are coal, oil and gas, oil shale, and certain aluminum-bearing minerals. These minerals are available for lease on Federal land not closed to leasing. Moreover, on acquired Federal land, minerals that are otherwise locatable are available only by lease. The Federal Government determines when available land can be leased, and lease agreements may include stipulations to protect other resource values that further condition lessee actions.

Certain specified mineral materials are available only by sale under the Materials Act of 1947 and the Surface Resources Act of 1955; these salable minerals include common varieties of sand and gravel, stone, clay, pumice, pumicite, and cinders. Sale of such minerals is entirely within the discretion of the land managing agency and, thus, is subject to close Federal control. Salable minerals are not included in the study because they are generally widespread and readily available in most places.

Land Management

Specific laws, regulations, and policies of Federal agencies govern the availability of land under their jurisdiction. The Federal Land Policy and Management Act of 1976 (FLPMA) and the Forest and Rangeland Renewable Resources Planning Act of 1974, as amended by the National Forest Management Act of 1976, are comprehensive statutes directing BLM and FS, respectively, in the management of Federal land under their jurisdiction. Each agency has established a multiple-use land planning system, described in more detail in appendix E, through which land managers can control mineral activities to protect other resources and ensure compatibility with land use plans and environmental protection objectives. Both agencies have authority to regulate mining and mineral leasing activity on land they manage. Each agency has published regulations designed to minimize adverse environmental impacts on surface resources, which may result from mining activities under the General Mining Law of 1872, as amended. Activities under the mineral leasing acts are at the discretion of the Secretary of the Interior, although certain terms are specified. Lease stipulations to protect other resources in the area may range from "standard stipulations" to highly restrictive, site-specific stipulations, or the Secretary may decide not to lease a specific area.

Land use planning documents indicate the management direction for specific areas of Federal land and show where mineral activity would be restricted if that activity is considered to be inconsistent with the planned use or capability of an area. Such restrictions are usually established at local levels of management and are applied mostly to mineral leasing.

Section 204 of FLPMA deals specifically with withdrawals and reservations. It repeals most existing withdrawal authorities, reserving to Congress the authority for some withdrawals and reservations but granting the Secretary of the Interior broad withdrawal authority, including the explicit authority to withdraw land from the General Mining Law of 1872, subject to strict congressional control. Standard and emergency withdrawals are allowed; they are temporary (except that withdrawals for a "resource use" may be for whatever period the Secretary deems desirable) but may be renewed. In addition, section 204 requires that all pending withdrawals be processed within 15 years or be dropped, and most existing withdrawals in the 11 Western States must be reviewed within 15 years.

AVAILABILITY OF FEDERAL LAND

The General Mining Law of 1872 provided, "that all valuable mineral deposits in lands belonging to the United States, both surveyed and unsurveyed, are hereby declared to be free and open to exploration and purchase, and the lands in which they are found to occupation and purchase . . ." Subsequently, many laws, regulations, and administrative policies have modified the broad scope of the 1872 Mining Law, greatly increasing the amount of Federal land that is unavailable or restricted to exploration and development.

In this study, restrictions are described in three ways so that their effect on mineral exploration and development can be fully examined. Depending upon the reader's in-

terest, restrictions may be viewed according to severity and authority (how), agency (who), or purpose (why).

Severity of and Authority for Restrictions

To assess availability in terms of the practical effect of restrictions on Federal land, the Bureau of Mines applied the following definitions:

Available.—Land where energy and mineral resource development is routinely initiated by private industry. The managing agency's policy does not discourage or preclude mineral exploration and/or development.

Slightly to moderately restricted.—Land where the practical effect of legal constraints or agency management policy is such that it may discourage private industry from initiating mineral exploration and/or development.

Unavailable or severely restricted.—Land that is closed to operation of some or all mineral laws or areas where the practical effect of legal constraints or management policy

will greatly discourage private industry from initiating exploration and/or development.

Availability was further classified according to the authority—legal or management—for the restrictions. Table 2 shows restrictions that affect mineral exploration and development; see appendix B for examples and additional details.

Plates 1 to 5 (in envelope) show the availability of Federal land based on the above classification of restrictions. Owing to the small map scale (1:500,000), only unavailable or severely restricted areas larger than 1 mi² are shown on the plates. Complete data, including the acreage of smaller unavailable or severely restricted areas, and moderately or slightly restricted areas, are given in the text and tables.

In Colorado, the availability status of Federal land for mineral exploration and development (fig. 2), regardless of mineral favorability, is as follows (in acres, rounded):

Table 2.—Categories of Federal land and restrictions that affect mineral exploration and development activities on it

Land category	Restrictions
Available.....	None from groups below; only standard stipulations (leasing) or surface protection regulations.
Slightly to moderately restricted:	
Legal restrictions.....	Stockraising Homestead Act patents. Powerite withdrawals (Public Law 359). Periodic (seasonal) limitations on surface occupancy.
Management restrictions.....	Management for primary purposes where mineral activities would be subordinated (e.g., areas of critical environmental concern, big-game winter habitat, some recreation or scenic areas). Rights-of-way and special land use permits.
Unavailable or severely restricted:	
Legal restrictions.....	Acts of Congress specifically limiting mineral activity. Formal withdrawals (specific ones may be closed to mineral location and/or leasing). Notices of reentry action with varying segregative effect. Nonrestoration of acquired lands to entry or leasing.
Management restrictions.....	Specification of "no leasing" or "no surface occupancy." Designation of lands as wilderness study areas (all types). Use of lands for military reservations not formally closed. Use of lands for wildlife refuges not formally closed. Applications with segregating effect. Designation of lands as unsuitable for surface coal mining under Public Law 95-87. No formal closing, but a set-aside of lands for purposes that are stated to be incompatible with mineral activities.

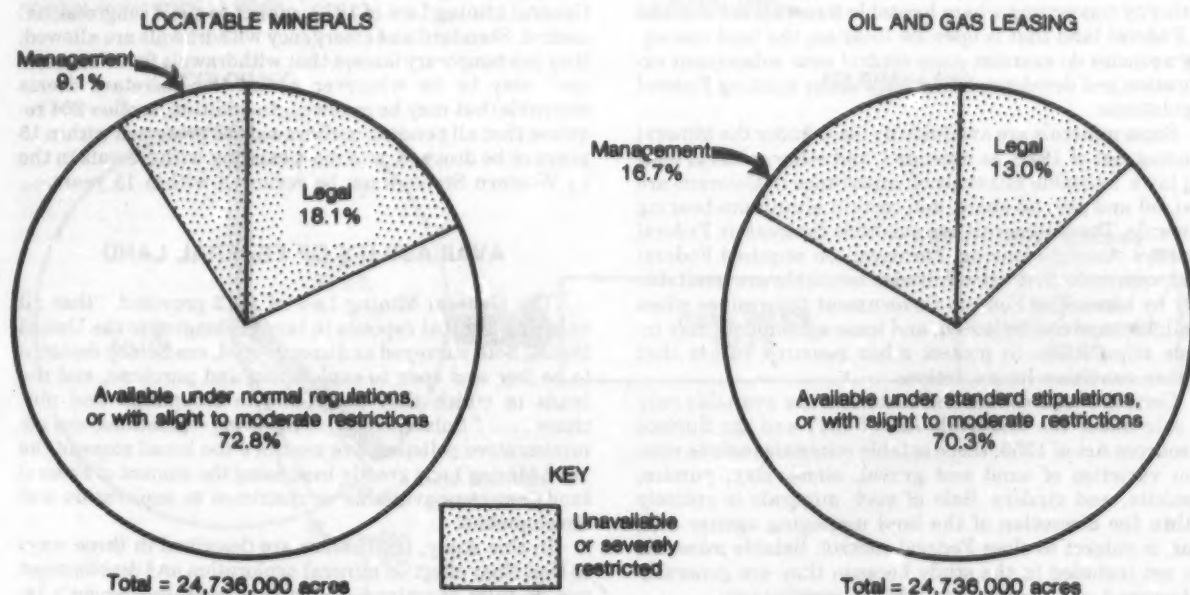


Figure 2.—Availability of Federal land in Colorado for mineral exploration and development.

Availability status	Locatable minerals	Oil and gas leasing
Available	11,972,000	13,108,000
Slightly to moderately restricted:		
Management	6,048,000	4,278,000
Unavailable or severely restricted:		
Legal	4,476,000	3,221,000
Management	2,243,000	4,132,000
Total	24,739,000	24,739,000

Managing Agencies

Federal agencies' land management practices fall into two classes depending upon their mission or purpose. On one hand, FS and BLM manage most land for multiple uses, although a substantial acreage is managed primarily for specific purposes such as wilderness. Conversely, all other

Federal agencies manage land that has been set aside for particular purposes, such as parks, wildlife refuges, or military reservations. In general, lands managed under the multiple-use concept are available for mineral exploration and development unless specifically withdrawn or restricted, while lands dedicated to special purposes or uses are closed or severely restricted to such activity. The availability status of Federal land managed by specific agencies is shown in table 3 for locatable minerals and table 4 for oil and gas leasing. Details of availability by agency are given in appendix E.

Purposes of Restrictions

Restrictions also can be classified by the purpose for which they are made. Common to each purpose, however, is a desire to protect certain resources or to provide for a particular use that would be incompatible with mineral ex-

Table 3.—Availability of Federal land, by agency and restriction category—locatable minerals—acres, rounded

Managing agency	Total	Available ¹	Slightly to moderately restricted: management	Unavailable or severely restricted	
				Legal	Management
Department of Agriculture:					
Forest Service	14,895,000	8,103,000	3,009,000	2,946,000	837,000
Agricultural Research Service	15,000	0	0	0	15,000
Department of the Interior:					
Bureau of Land Management	8,346,000	3,675,000	2,958,000	867,000	846,000
National Park Service	598,000	0	0	598,000	0
Bureau of Reclamation	243,000	0	81,000	162,000	0
Fish and Wildlife Service	60,000	1,000	0	0	59,000
Department of Defense:					
Department of the Army	423,000	0	0	3,000	420,000
Army Corps of Engineers	38,000	0	0	(?)	38,000
Department of the Air Force	29,000	0	0	9,000	20,000
Department of Energy	85,000	0	0	82,000	3,000
Others	7,000	0	0	2,000	5,000
Subtotal	24,739,000	11,779,000	6,048,000	4,669,000	2,243,000
Adjustment ³	0	193,000	0	(193,000)	0
Total	24,739,000	11,972,000	6,048,000	4,476,000	2,243,000

¹Remainder of category, by difference.

²Less than 500 acres.

³Land subject to multiple withdrawals and withdrawals where there is no Federal surface.

Table 4.—Availability of Federal land, by agency and restriction category—oil and gas leasing—acres, rounded

Managing agency	Total	Available ¹	Slightly to moderately restricted: management	Unavailable or severely restricted	
				Legal	Management
Department of Agriculture:					
Forest Service	14,195,000	8,539,000	1,077,000	2,599,000	2,880,000
Agricultural Research Service	15,000	0	0	0	15,000
Department of the Interior:					
Bureau of Land Management	8,346,000	4,542,000	2,958,000	(?)	846,000
National Park Service	598,000	0	0	556,000	42,000
Bureau of Reclamation	243,000	0	243,000	(?)	0
Fish and Wildlife Service	60,000	0	0	0	60,000
Department of Defense:					
Department of the Army	423,000	0	0	(?)	423,000
Army Corps of Engineers	38,000	0	0	(?)	38,000
Department of the Air Force	29,000	0	0	9,000	20,000
Department of Energy	85,000	27,000	0	58,000	2,000
Others	7,000	0	0	1,000	6,000
Total	24,739,000	13,108,000	4,278,000	3,221,000	4,132,000

¹Remainder of category, by difference.

²Less than 500 acres.

ploration and development. Some of the purposes transcend Federal agencies; others coincide closely with a particular agency.

Protection of wild and natural areas, including wilderness preservation, is the foremost reason why Federal land is unavailable or severely restricted in Colorado; more than 4.3 million acres are dedicated or under consideration for these purposes. Other reasons include protection of

scenic, historic, and recreational values; reservation for military use; protection of fish and wildlife; conservation of minerals (e.g., naval oil shale reserves); energy development (e.g., powersite withdrawals); and surface occupancy (e.g., hospitals and cemeteries) or surface development (e.g., public water supply). The purposes of restrictions are discussed in detail in appendix F.

MINERAL FAVORABILITY

Well known for its mining heritage, Colorado is generously endowed with a wide variety of metallic, nonmetallic, and mineral fuel commodities (48). Much of the State is favorable for one or more mineral commodities or groups. Many are critical and strategic minerals that are especially important to the Nation.

The United States presently stockpiles about 75 mineral commodities because they are critical and strategic materials (44). Colorado produces or has significant deposits of at least 18 of these commodities. The State is an important past or present domestic source of beryllium, fluorspar, lead, silver, tin, tungsten, vanadium, and zinc; moreover, deposits of aluminum, columbium, thorium, and titanium, are important potential domestic sources of these critical minerals. Other critical minerals, including petroleum and uranium, are also produced in Colorado, although the State contributes a smaller percentage of the national output. The Nation's premier deposits of oil shale occur in Colorado.

COLORADO MINERAL PRODUCTION

For 125 years, mineral production has been an economic mainstay in Colorado. As first, gold and silver were the dominant products, supplemented later by lead and zinc. Coal was the leading mineral product from 1917 to 1947, when petroleum assumed that role. Since World War I, the State has been a dominant source of molybdenum and vanadium, and an important domestic producer of tungsten, uranium, and several other minerals.

The cumulative value of mineral production (1859-1982) from the State exceeds \$25 billion. Petroleum, coal, gold, molybdenum, silver, zinc, and lead account for about 80% of the value. Yet several other commodities, though of lesser dollar value, are just as important nationally, owing to their strategic nature; in this category are vanadium and uranium, tin and tungsten, and beryllium and fluorspar.

Except for a decline from 1920 to 1932, the annual value of production has increased quite steadily until 1981, when molybdenum production declined sharply. Colorado has ranked among the leading States in the Nation in value of mineral production in most recent years. Each year, 25 to 30 mineral commodities (metals, nonmetals, and mineral fuels) are produced.

For the selected minerals in this study, the value of production reached \$2.3 billion in 1982 (table 5). That year, the State led the Nation in production of carbon dioxide, molybdenum, and vanadium, ranked second in tin and tungsten, third in lead, fifth in gold, sixth in zinc, and seventh in silver. Statewide, the per capita value of mineral production was \$750, and the value per square mile averaged \$23,000. The mineral industry employed 41,200 people in the State.

Table 5.—Selected mineral production in Colorado, 1982

Mineral	Quantity	Value ¹
Metals and nonmetals:		
Copper	575 mt.	\$941,000
Gem stones	NA	80,000
Gold	64,584 tr. oz.	24,278,000
Molybdenum	39,006,000 lb.	159,925,000
Silver	1,934,000 tr. oz.	15,378,000
Combined value of beryllium concentrate, carbon dioxide, iron ore, lead, pyrites, tin, tungsten ore and concentrates, vanadium, and zinc	NAp	49,993,000
Subtotal		250,595,000
Mineral fuels:		
Coal	18,318,000 st.	411,513,000
Natural gas	209,892,000 Mcf.	664,323,000
Petroleum	30,545,000 bbl.	964,306,000
Uranium	W	W
Subtotal		2,040,142,000
Total		2,290,737,000

NA Not available. NAp Not applicable.

W Withheld to avoid disclosing company proprietary data; value not included in totals.

¹Rounded.

Source: Bureau of Mines and U.S. Department of Energy data.

Federal land in Colorado is an important source of mineral production. As of September 30, 1982, leases and licenses (38) were in effect for a number of minerals on Federal land. The minerals and land acreage are as follows:

Oil and gas	8,728,695
Coal	276,251
Geothermal resources	16,874
Sodium	10,998
Oil shale	10,184
Tar sands	10,184
Potassium	632

Mineral production (38) from Federal land during fiscal year 1982 included the following:

Carbon dioxide	Mcf. 895,821
Coal	st. 9,157,131
Liquefied petroleum gas	gal. 12,930,463
Natural gas	Mcf. 53,163,780
Oil shale	st. 14,912
Petroleum	bbl. 8,955,887
Sodium	st. 5,939

The production or value of locatable minerals from Federal land is not recorded, but 205,000 unpatented mining claims of record with BLM in the State are an indication of favorability and exploration interest in Federal land for these minerals. Much of the production of locatable

minerals comes from unpatented mining claims on Federal land and from patented mining claims (private land) that were Federal land before they were patented.

GEOLOGIC AND GEOGRAPHIC SETTING

Mineral deposits are products of specific geologic processes, and thus they occur only in geologic environments where those processes have operated (35-36, 48). As the geology of Colorado varies widely from place to place, so do the types of mineral deposits.

Colorado may be divided into three regions, including parts of four physiographic provinces (fig. 3), distinct in geology, mineral deposits, and other respects (12). The Great Plains Province, east of the Rocky Mountains, is characterized by relatively undisturbed sedimentary rocks of varying thickness; the region is primarily favorable for mineral fuels. The mountain region, including parts of the Southern Rocky Mountain and the Wyoming Basin Provinces, is a region of complex geology; ancient metamorphic rocks, geologically old and young intrusive and volcanic rocks, and sedimentary rocks are complexly folded and faulted. This region is noted for varied metallic minerals, but important nonmetals and mineral fuels also occur. The Colorado Plateau Province, west of the mountain region, is characterized by uplifted, flat-lying or gently folded,

deeply incised sedimentary rocks; mineral fuels are particularly important, but some metals and nonmetals also occur.

Entire physiographic provinces are not equally favorable, however, for the mineral deposits noted above. Although regional geology controls the types of mineral deposits that may occur in a province, more specific geologic processes determine where the mineral deposits occur.

Selected Metallic and Nonmetallic Minerals

Plate 1 shows areas in Colorado that are favorable for deposits of selected metallic and nonmetallic minerals having relatively high unit value and localized minable occurrence. These minerals are sought wherever they may occur. These minerals are locatable on public domain land under the General Mining Law of 1872, as amended, and availability restrictions are much the same for all of them.

Comprehensive reviews of these mineral deposits and/or maps of the mining districts in Colorado have been prepared by the Colorado Land Use Commission (6), Del Rio (9), Hill and Lindgren (16), Mardirosian (20), Tweto (35), USGS (48), and Vanderwilt (52).

Most metals (except aluminum, uranium, and vanadium, which are shown on other maps) and certain industrial minerals are included, but construction and common industrial minerals are excluded. The selected locatable

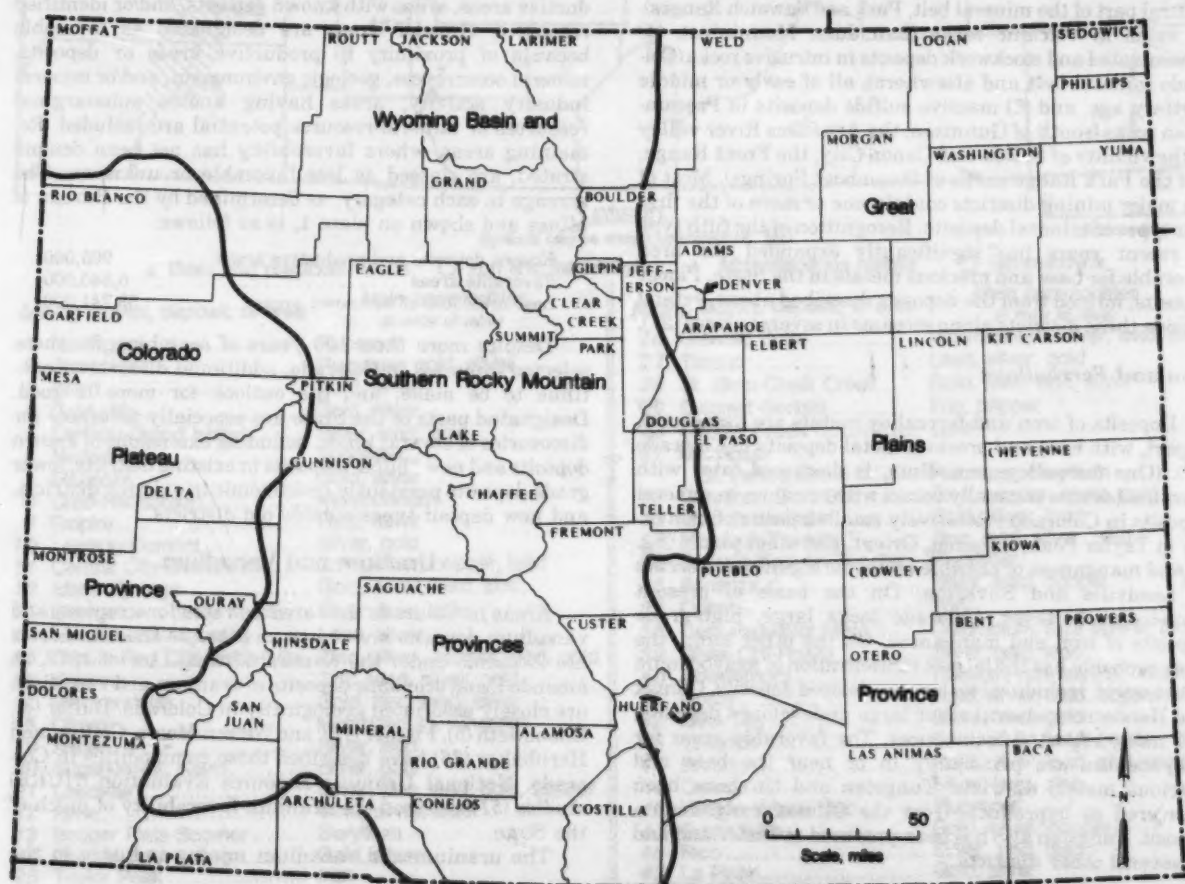


Figure 3.—Physiographic provinces of Colorado. (Modified from Fenneman (12).)

minerals that are important in Colorado are grouped for discussion as follows:

Base and precious metals—gold, silver, lead, zinc, and copper, and associated minor metals: antimony, arsenic, bismuth, cadmium, selenium, and tellurium.

Iron and ferroalloys—iron, molybdenum, tungsten, tin, and manganese.

Miscellaneous metals—beryllium, columbium, rare earths, thorium, titanium, and tantalum.

Nonmetallics—fluorspar, barite, diamonds and other gem stones, sulfur, and the pegmatite minerals: quartz, feldspar, and mica.

Most of the major deposits and mining districts of these minerals (fig. 4) are in the Southern Rocky Mountain Province.

Base and Precious Metals

Base and precious metals usually are associated in varying proportions in Colorado deposits. Individual deposits frequently are clustered and the area is known as a mining district. Most of the major districts lie in a zone called the Colorado mineral belt that extends from Boulder County southwest almost to the corner of the State (fig. 4). Romberger (30) and Tweto (35) have grouped these mineral deposits in the State into five main types: (1) veins in Precambrian rocks (Front Range part of the mineral belt), (2) veins and replacement deposits in sedimentary rocks (central part of the mineral belt, Park and Sawatch Ranges), (3) veins in volcanic rocks (San Juan Mountains), (4) disseminated and stockwork deposits in intrusive rocks (Colorado mineral belt and elsewhere), all of early or middle Tertiary age, and (5) massive sulfide deposits in Precambrian rocks (south of Gunnison, the Arkansas River valley in the vicinity of Salida and Canon City, the Front Range, and the Park Range north of Steamboat Springs). Most of the major mining districts contain one or more of the first four types of mineral deposits. Recognition of the fifth type in recent years has significantly expanded the area favorable for base and precious metals in the State. Placer deposits, formed from the deposits described above, extend outside these districts along streams in several places (27).

Iron and Ferroalloys

Deposits of iron and ferroalloy metals are associated, in part, with base and precious metal deposits in Colorado (48). (One ferroalloy, vanadium, is discussed later with uranium because it usually occurs with uranium in mineral deposits in Colorado.) Relatively small deposits of iron occur at Taylor Peak, Calumet, Orient, and other places (fig. 4), and manganese of possible economic significance occurs at Leadville and Silverton. On the basis of present knowledge, however, Colorado lacks large, high-grade deposits of iron and manganese. On the other hand, the State probably has the largest concentration of molybdenum in the world, including two large developed deposits, Climax and Henderson; several other large undeveloped deposits; and many reported occurrences. The favorable areas for molybdenum are principally in or near the base and precious metals districts. Tungsten and tin have been recovered as byproducts from the Climax molybdenum deposit. Tungsten also has been produced at Nederland and at several other districts.

Miscellaneous Metals

The miscellaneous metals occur mostly separate from the above groups. One large beryllium deposit is at Badger Flats (fig. 4); this area may contain other similar deposits. Smaller deposits of beryllium, plus tantalum, quartz, feldspar, mica, and gem stones occur in several pegmatite districts (15). Substantial deposits of columbium, rare earths, thorium, and titanium are associated with alkaline rocks at Powderhorn and Gem Park-Wet Mountains (48); these districts are regarded as favorable for one or more of those metals.

Nonmetallics

Nonmetallic minerals such as fluorspar, barite, and sulfur are sometimes associated with base and precious metal deposits in certain districts. In past years, Colorado was an important domestic source of fluorspar, principally from districts at Northgate, Jamestown, Browns Canyon-Poncha, and Wagon Wheel Gap (fig. 4). Sulfur has been obtained from pyrite recovered in mineral deposits at Climax and Rico; sulfur deposits are also known in areas of volcanic rocks in the San Juan Mountains. The 1975 discovery of diamonds along the Colorado-Wyoming border northwest of Fort Collins indicates an area favorable for this mineral.

Highly favorable areas for the selected locatable minerals include productive mining districts and other productive areas; areas with known deposits, and/or identified resources. Broader areas are designated as favorable because of proximity to productive areas or deposits, mineral occurrences, geologic environment, and/or mineral industry activity; areas having known submarginal resources or mineral-resource potential are included. Remaining areas, where favorability has not been demonstrated, are classed as less favorable or unknown. The acreage in each category, as determined by the Bureau of Mines and shown on plate 1, is as follows:

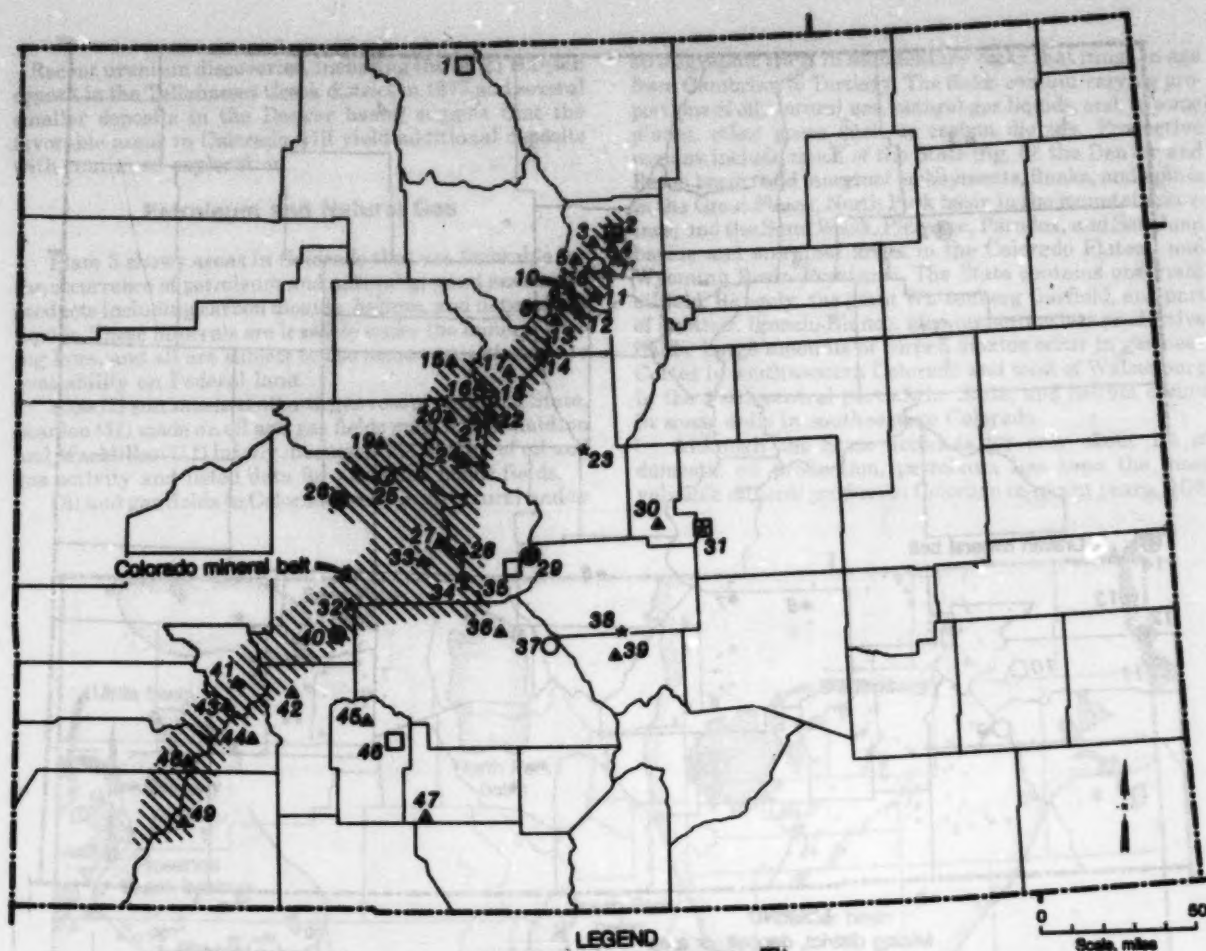
Known deposits and productive areas	905,000
Favorable areas	5,840,000
Less favorable or unknown areas	59,741,000

Despite more than 100 years of searching for these selected minerals in Colorado, additional discoveries continue to be made, and the outlook for more is good. Designated parts of the State are especially favorable for discoveries of several kinds, including extensions of known deposits and new "blind" deposits in existing districts, lower grade deposits previously uneconomic in existing districts, and new deposit types outside old districts.

Uranium and Vanadium

Areas in Colorado that are favorable for uranium and vanadium deposits are shown on plate 2. These minerals are locatable under the General Mining Law of 1872, as amended, and economic deposits of uranium and vanadium are closely associated geologically in Colorado. Butler (4), Chenoweth (5), Fischer (13), and Nelson-Moore, Collins, and Hornbaker (26) have described these commodities in Colorado. National Uranium Resource Evaluation (NURE) studies (51) assessed the uranium favorability of much of the State.

The uranium and vanadium mining industry in the



LEGEND

(Symbols may be shown combined: i.e., $\Delta\Box$)

Δ Base and precious metals $\circ$ Iron and ferroalloys $\star$ Miscellaneous metals $\Box$ Nonmetallics

Mining district, deposit, or area	Main commodities (in order of value)
1 Northgate	Fluorspar
2 Jamestown	Fluorspar, gold, silver
3 Ward	Gold, silver
4 Gold Hill	Gold, silver
5 Caribou-Grand Island	Silver, lead, gold
6 Nederland	Tungsten
7 Magnolia	Gold, silver
8 Urad-Henderson	Molybdenum
9 Empire	Gold, silver
10 Lawson-Dumont	Silver, gold
11 Central City-Blackhawk	Gold, silver, copper, lead
12 Idaho Springs	Gold, silver, lead, zinc
13 Georgetown-Silver Plume	Silver, lead, zinc
14 Montezuma-Argentine	Lead, silver
15 Gilman-Red Cliff-Battle Min.	Zinc, silver, copper, lead, gold
16 Kokomo	Zinc, lead, silver, gold
17 Breckenridge	Gold, zinc, lead, silver
18 Climax	Molybdenum, tungsten
19 Aspen	Silver, lead
20 Sugarloaf-St. Kevin	Silver, gold
21 Leadville	Silver, zinc, lead, gold, copper
22 Alma	Gold, silver, lead
23 Badger Flats-Boomer	Beryllium
24 Granite-Twin Lakes	Gold, silver
25 Taylor Peak	Iron

Mining district, deposit, or area	Main commodities (in order of value)
26 Crested Butte	Molybdenum, silver, lead, zinc
27 Tincup	Lead, silver, gold
28 St. Elmo-Chalk Creek	Gold, lead, zinc, silver
29 Calumet-Sedalia	Iron, copper
30 Cripple Creek	Gold
31 Mt. Rosa	
St. Peters Dome	Fluorspar, beryllium
32 Gunnison Gold Belt	Zinc, copper, silver, gold
33 Gold Brick-Pitkin	Gold, silver, lead
34 Monarch-Tomichi	Zinc, lead, silver, gold
35 Browns Canyon-Poncha	Fluorspar
36 Bonanza	Silver, lead, copper
37 Orient	Iron
38 Gem Park-Wet Mtns.	Columbium, rare earths, thorium
39 Silver Cliff-Rosita	Silver, gold, lead
40 Powderhorn	Titanium, rare earths, columbium
41 Ouray	Gold, silver, lead, copper, zinc
42 Lake City	Silver, lead, gold
43 Telluride	Gold, silver, lead, copper, zinc
44 Silverton	Gold, silver, lead, zinc, copper
45 Creede	Silver, lead, zinc
46 Wagon Wheel Gap	Fluorspar
47 Summitville	Gold, silver, copper
48 Rico	Silver, zinc, lead
49 La Plata	Gold, silver

Figure 4.—Major metallic and nonmetallic mining districts and deposits of Colorado, excluding construction materials and pegmatites. (Modified from Romberger (30), Tweto (35), and USGS (48).)

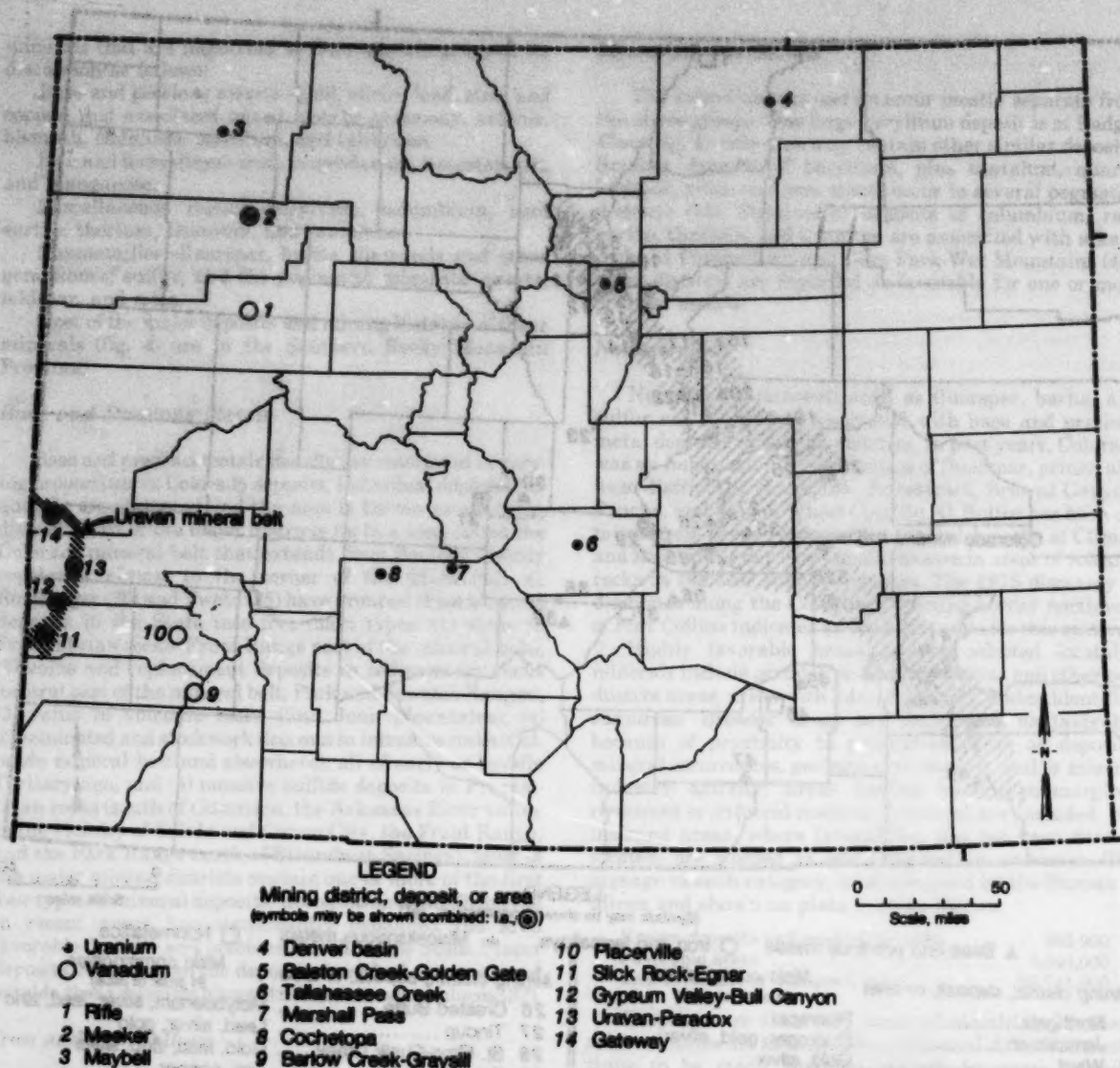


Figure 5.—Major uranium and vanadium mining districts and deposits of Colorado. (Modified from Chenoweth (5) and Fischer (13).)

United States began in Colorado, and the State continues as an important source of both minerals. Figure 5 shows the major known uranium and vanadium mining districts in Colorado.

Two broad types of uranium and vanadium deposits occur in Colorado. Most important are deposits in sedimentary rocks, principally sandstones. Those in the Uravan mineral belt have been most productive; uranium and vanadium occur together in varying proportions. Deposits at Placerville, Rifle, and a few other places, however, are principally vanadium-bearing, while deposits at Maybell, Tallahassee Creek, and in the Denver basin contain uranium without appreciable vanadium.

Vein deposits of uranium, in a wide variety of host rocks, are the second major type. Included are the Ralston Creek district, deposits in Gunnison and Saguache Counties, and many smaller occurrences. The largest single uranium mine in Colorado, the Schwartzwalder at Ralston Creek, is a vein deposit.

The U.S. Department of Energy (DOE) (5) estimated that reserves of uranium in Colorado are 11,400 st at \$15/lb U_3O_8 (triuranium octoxide) and 44,000 st at \$50/lb U_3O_8 . Additional uranium is in less certain or lower grade categories.

Data on uranium favorability from the NURE studies (51) and other sources were used to delineate the favorable areas shown on plate 2. The more favorable areas include known deposits and productive areas of uranium and vanadium. Remaining areas, where favorability has not been demonstrated, are classed as unfavorable or unevaluated. The acreage in each category, as determined by the Bureau of Mines and shown on plate 2, is as follows:

Uranium:	
Known deposits and productive areas	206,000
Favorable areas	7,456,000
Unfavorable or unevaluated areas	58,825,000
Vanadium: Known deposits and productive	
or favorable areas	870,000

Recent uranium discoveries, including the large Hansen deposit in the Tallahassee Creek district in 1977 and several smaller deposits in the Denver basin, suggest that the favorable areas in Colorado will yield additional deposits with continued exploration.

Petroleum and Natural Gas

Plate 3 shows areas in Colorado that are favorable for the occurrence of petroleum and natural gas and associated products including carbon dioxide, helium, and natural gas liquids. These minerals are leasable under the mineral leasing laws, and all are subject to the same restrictions as to availability on Federal land.

Bas (7) summarized oil and gas resources in the State, Scanlon (31) made an oil and gas fields map, and Donaldson and MacMillan (11) briefly discussed the history of oil and gas activity and listed data for all of the major fields.

Oil and gas fields in Colorado occur in structural and/or

stratigraphic traps in sedimentary rocks that range in age from Cambrian to Tertiary. The fields contain varying proportions of oil, natural gas, natural gas liquids, and, in some places, other gases such as carbon dioxide. Productive regions include much of the State (fig. 6): the Denver and Raton basins and marginal embayments, flanks, and uplifts in the Great Plains; North Park basin in the mountain province; and the Sand Wash, Piceance, Paradox, and San Juan basins and marginal areas in the Colorado Plateau and Wyoming Basin Provinces. The State contains one giant oilfield, Rangely, the giant Wattenberg Gasfield, and part of another, Ignacio-Blanco, plus numerous less productive fields. Large amounts of carbon dioxide occur in gas near Cortez in southwestern Colorado and west of Walsenburg in the south-central part of the State, and helium occurs in some wells in southeastern Colorado.

Although the State accounts for only about 1% of domestic oil production, petroleum has been the most valuable mineral product in Colorado in recent years. DOE

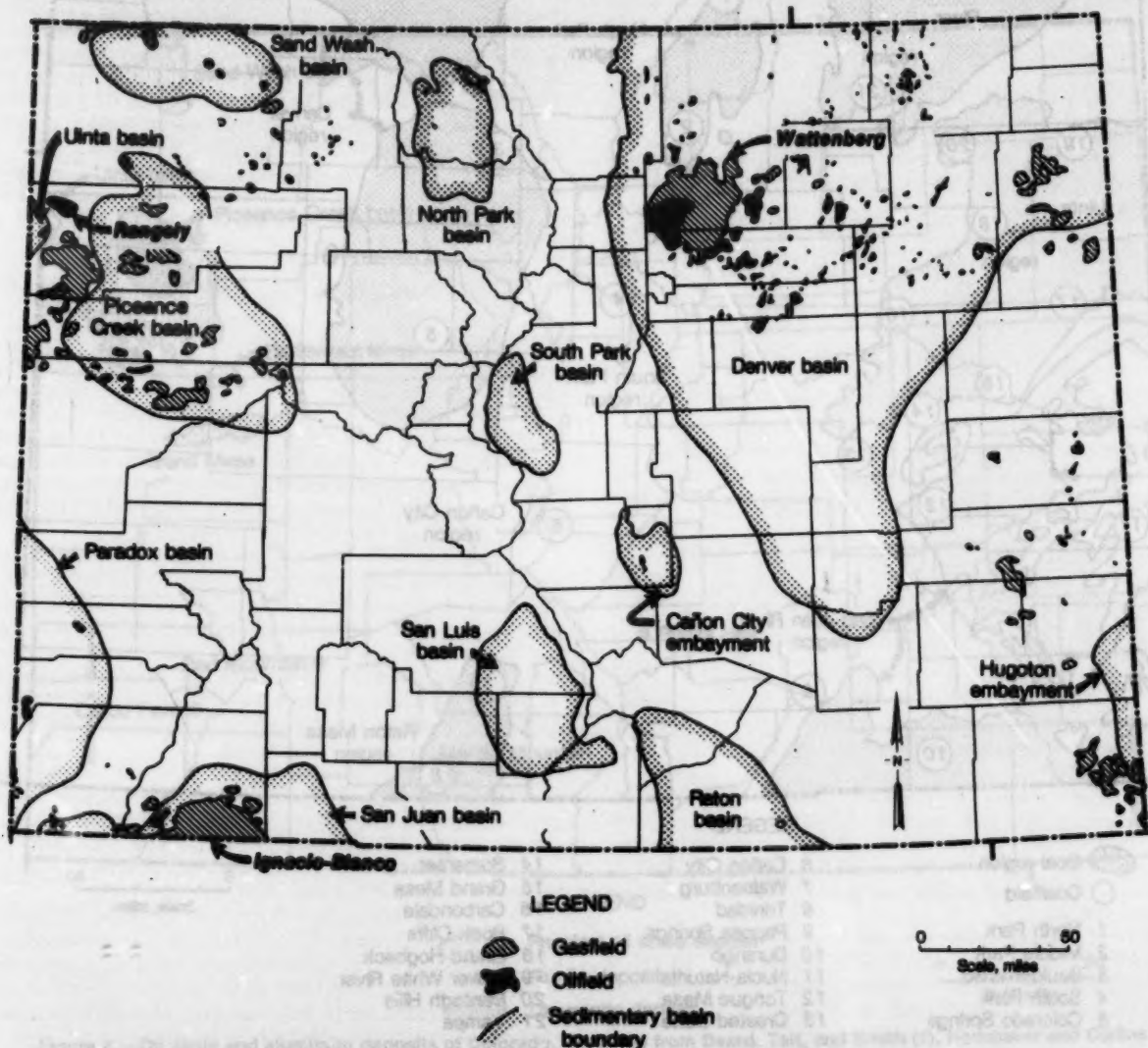


Figure 6.—Oil and gas fields and sedimentary basins of Colorado. (Modified from Scanlon (31).)

estimated crude oil reserves for Colorado at 194 million bbl, natural gas liquids at 204 million bbl, and dry natural gas at 2.96 trillion ft³ as of 1981.

Favorable areas for oil and gas include oil and/or gas fields and adjacent areas of sedimentary rocks. Areas outside these productive regions are classed as permissible if sedimentary rocks capable of oil or gas production are known or believed to exist. Remaining areas are considered unfavorable for oil or gas. The acreage in each category, as determined by the Bureau of Mines and shown on plate 3, is as follows:

Oil and/or gas fields and adjacent areas of sedimentary rocks	32,669,000
Permissible areas	23,874,000
Unfavorable areas	9,943,000

Future discoveries of oil and gas in Colorado are likely, as even the productive regions of the State have not been

completely explored. Discoveries in deeper parts of the basins, in beds not previously considered productive, in subtle stratigraphic traps, in rocks with tightly held hydrocarbons, and in permissible but untested regions of the State will continue, aided by new technology for exploration and development.

Coal

Plate 4 shows areas in Colorado that are favorable for coal deposits. Coal is leasable under the Mineral Leasing Act of 1920, but its availability on Federal land is subject to special restrictions.

Coal occurs in bedded deposits in certain sedimentary rocks. Murray has prepared comprehensive summaries about Colorado coal (24-25). Figure 7 shows the 8 major coal regions and 21 coalfields. Most are in the Great Plains or Colorado Plateau Provinces, but three smaller regions oc-

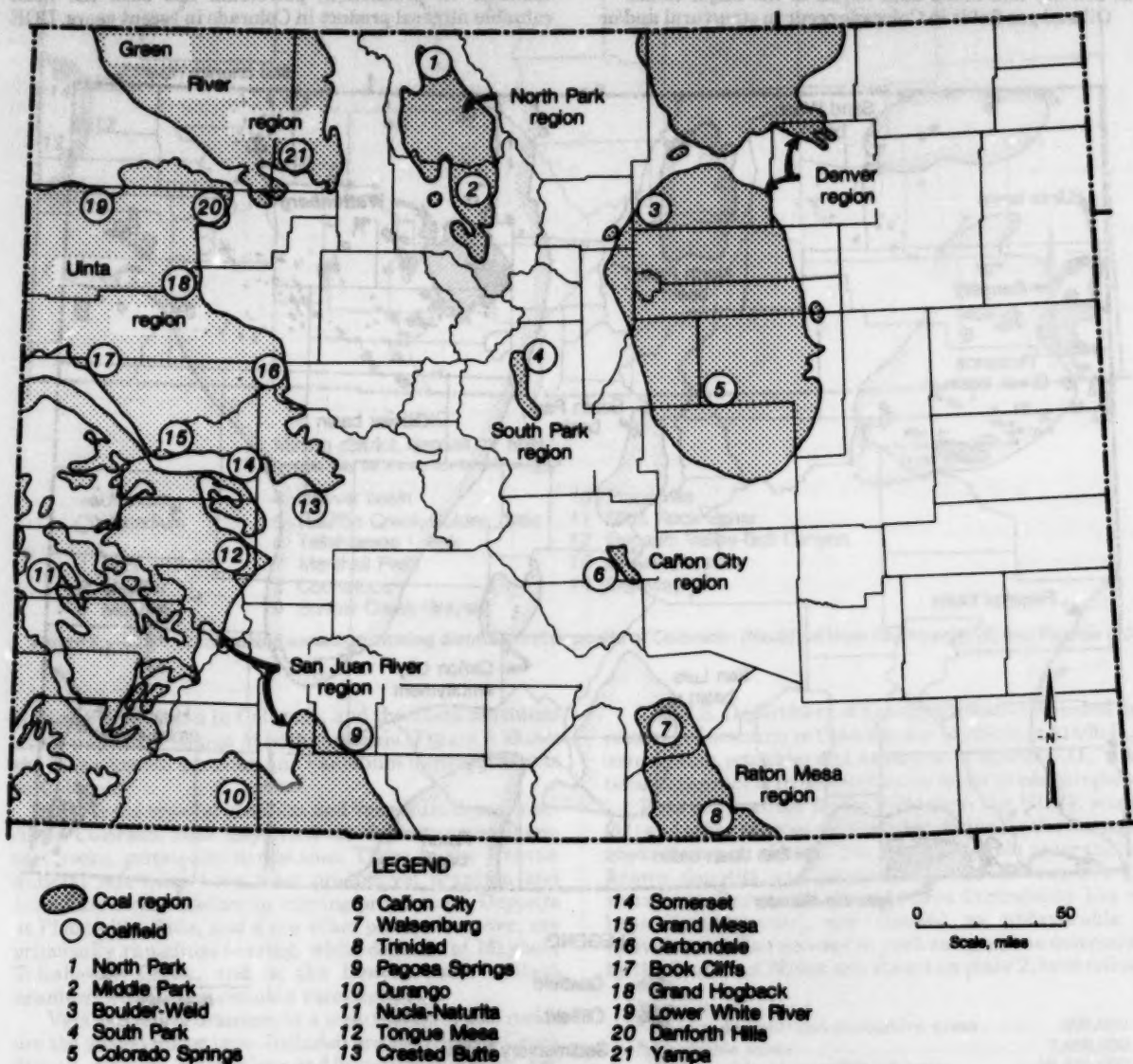


Figure 7.—Coalfields of Colorado. (Modified from Murray (24).)

cur in the mountain province. The coal-bearing rocks are geologically young, ranging in age from Late Cretaceous to Eocene. About 70% of the coal deposits are bituminous, 23% are subbituminous, and lesser amounts are lignite or anthracite in rank; most of the higher ranking coal is in western Colorado. Most of the coal is low in sulfur content (less than 1%), and much is high in heat value. Premium coking (metallurgical) coal occurs in the Raton Mesa, San Juan River, and southeastern Uinta coal regions. About two-thirds of present production is from surface mines and one-third is from underground mines, but most of the coal occurs at depth and ultimately must be mined by underground methods.

Colorado accounts for 2% to 3% of the annual domestic coal production, but the State contains about 11% of the Nation's total coal resources above a depth of 6,000 ft (25); remaining in-place coal resources are estimated at 434 billion st to a depth of 6,000 ft. The State ranks second nationally in remaining identified bituminous coal resources and first in remaining low-sulfur bituminous coal.

About 28% of Colorado is underlain by rocks that are

known to generally contain coal (50). These favorable areas for coal are shown on plate 4; the coal-bearing rocks lie at depths of less than 3,000 ft under 14,594,000 acres and at greater depths under an additional 3,955,000 acres. The distribution of recoverable deposits of coal within these areas is incompletely known.

Oil Shale and Aluminum

Plate 5 shows areas in Colorado that are favorable for deposits of oil shale and aluminum. Aluminum is shown with oil shale because the aluminum deposits also are subject to leasing and the major known deposit is closely associated with oil shale deposits.

Oil shale is a fine-grained sedimentary rock containing organic matter—but not free oil—that yields oil when heated to high temperatures (destructive distillation). Sediments in the Green River Formation contain the richest and thickest deposits of oil shale in the world. The beds underlie the Piceance Creek, Sand Wash, and Uinta basins in northwestern Colorado (fig. 8) and adjacent parts of Utah and

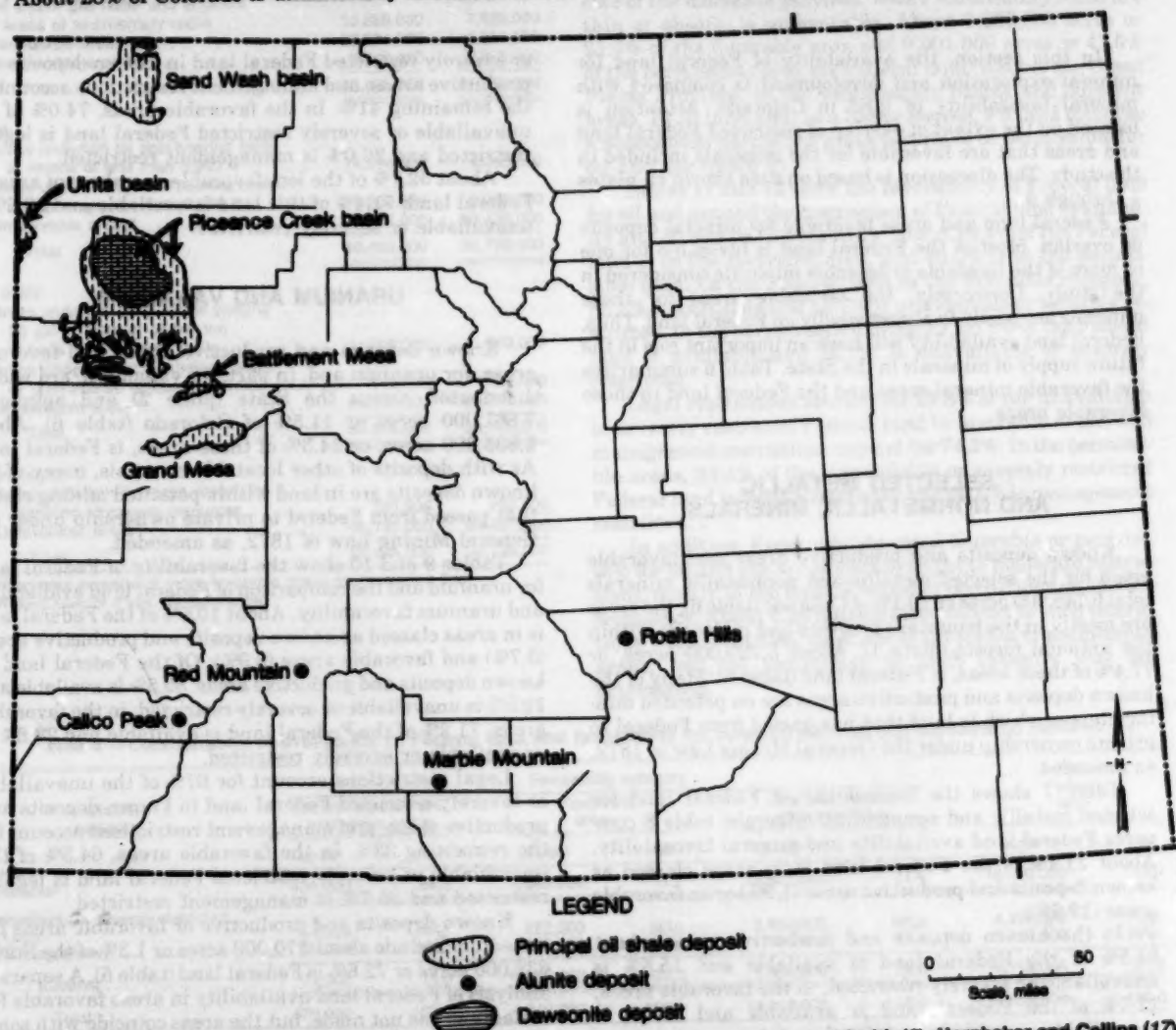


Figure 8.—Oil shale and aluminum deposits of Colorado. (Modified from Beard, Tait, and Smith (2), Hornbaker and Collins (17), and USGS and CGS (50).)

Wyoming; outliers are under Battlement Mesa and Grand Mesa, as well.

Oil content of the shale ranges from 5 to 60 gal/st over a thickness of as much as 2,000 ft. Interest has focused on material averaging 25 gal or more of oil per ton in beds at least 15 ft thick, which underlie the central part of the Piceance Creek basin (50).

Large deposits of dawsonite and alunite are found in Colorado and are potential sources of aluminum. (The United States has limited deposits of bauxite, the traditional source of the metal, and most of the aluminum used nationally comes from abroad.) The richest known dawsonite deposit is associated with oil shale in the central Piceance Creek basin (fig. 8), and the dawsonite probably could be recovered during processing of oil shale. The

Piceance Creek basin deposit contains an estimated 19 billion st of dawsonite (2).

Four deposits of alunite in southern Colorado also are possible sources of aluminum (14). The largest, at Red Mountain, is presently the subject of environmental and other studies, and contains 250 million st of 30% alunite.

As shown on plate 5, about 890,000 acres in Colorado is underlain by oil shale yielding 25 gal or more of oil per ton in beds at least 15 ft thick, and 449,000 acres is underlain by oil shale of lesser resource value or by unevaluated oil shale (50). The dawsonite deposit and the four alunite deposits underlie about 291,000 acres. Areas elsewhere in the State underlain by very low-grade oil shale or by other aluminum-bearing rocks were not considered significant at the time of this study and, therefore, are not shown on plate 5.

RELATIONSHIP OF FEDERAL LAND AVAILABILITY TO MINERAL FAVORABILITY

In this section, the availability of Federal land for mineral exploration and development is compared with mineral favorability of land in Colorado. Attention is focused on the extent of overlap of restricted Federal land and areas that are favorable for the minerals included in the study. The discussion is based on data shown on plates 1 through 5.

Federal land and areas favorable for mineral deposits do overlap. Most of the Federal land is favorable for one or more of the locatable or leasable minerals considered in the study. Conversely, the favorable areas for these minerals are partly to almost wholly on Federal land. Thus, Federal land availability will have an important role in the future supply of minerals in the State. Table 6 summarizes the favorable mineral areas and the Federal land in those favorable areas.

SELECTED METALLIC AND NONMETALLIC MINERALS

Known deposits and productive areas and favorable areas for the selected metallic and nonmetallic minerals total 6,745,000 acres or 10.1% of Colorado (table 6); the areas are mostly in the mountain province and many are within the national forests (plate 1). About 5,220,000 acres, or 77.4% of these areas, is Federal land (table 6). Many of the known deposits and productive areas are on patented mining claims, which is land that has passed from Federal to private ownership under the General Mining Law of 1872, as amended.

Table 7 shows the favorability of Federal land for selected metallic and nonmetallic minerals; table 8 compares Federal land availability and mineral favorability. About 21.1% of the Federal land is in areas classed as known deposits and productive areas (1.9%) or as favorable areas (19.2%).

In the known deposits and productive areas, about 84.5% of the Federal land is available and 15.5% is unavailable or severely restricted; in the favorable areas, 77.7% of the Federal land is available and 22.3% is unavailable or severely restricted.

Legal restrictions account for 59% of the unavailable

or severely restricted Federal land in known deposits and productive areas, and management restrictions account for the remaining 41%. In the favorable areas, 74.0% of the unavailable or severely restricted Federal land is legally restricted and 26.0% is management restricted.

About 32.7% of the less favorable or unknown areas is Federal land; 71.4% of this land is available and 28.6% is unavailable or severely restricted.

URANIUM AND VANADIUM

Known deposits and productive areas, and favorable areas, for uranium and, in part, for vanadium, are widely distributed across the State (plate 2) and aggregate 7,661,000 acres or 11.5% of Colorado (table 6). About 2,625,000 acres, or 34.3% of these areas, is Federal land. As with deposits of other locatable minerals, many of the known deposits are in land within patented mining claims that passed from Federal to private ownership under the General Mining Law of 1872, as amended.

Tables 9 and 10 show the favorability of Federal land for uranium and the comparison of Federal land availability and uranium favorability. About 10.6% of the Federal land is in areas classed as known deposits and productive areas (0.7%) and favorable areas (9.9%). Of the Federal land in known deposits and productive areas, 89.5% is available and 10.5% is unavailable or severely restricted; in the favorable areas, 71.2% of the Federal land is available and 28.8% is unavailable or severely restricted.

Legal restrictions account for 67% of the unavailable or severely restricted Federal land in known deposits and productive areas, and management restrictions account for the remaining 33%. In the favorable areas, 64.3% of the unavailable or severely restricted Federal land is legally restricted and 35.7% is management restricted.

Known deposits and productive or favorable areas for vanadium include about 870,000 acres or 1.3% of the State; 632,000 acres or 72.6% is Federal land (table 6). A separate analysis of Federal land availability in areas favorable for vanadium was not made, but the areas coincide with some of those favorable for uranium (plate 2).

Table 6.—Mineral favorability in Colorado and in Federal land, acres, rounded

Mineral commodity or group and favorability category	Total	Federal
Selected metallic and nonmetallic minerals:		
Known deposits and productive areas	605,000	478,000
Favorable areas ¹	5,840,000	4,742,000
Less favorable or unknown areas ²	59,741,000	19,519,000
Total	66,486,000	24,739,000
Uranium:		
Known deposits and productive areas	205,000	171,000
Favorable areas ¹	7,456,000	2,454,000
Unfavorable and unevaluated areas ²	58,825,000	22,114,000
Total	66,486,000	24,739,000
Vanadium:		
Known deposits and productive or favorable areas	870,000	632,000
Unfavorable areas ²	65,616,000	24,107,000
Total	66,486,000	24,739,000
Oil and gas:		
Oil and/or gas fields and adjacent areas of sedimentary rocks	32,669,000	7,023,000
Permissible areas ¹	23,874,000	9,901,000
Unfavorable areas ²	9,943,000	7,815,000
Total	66,486,000	24,739,000
Coal:		
Areas underlain by coal-bearing rocks at depths of less than 3,000 ft	14,594,000	4,046,000
Areas underlain by coal-bearing rocks at depths greater than 3,000 ft	3,955,000	2,263,000
Unfavorable areas ²	47,937,000	18,430,000
Total	66,486,000	24,739,000
Oil shale:		
Areas underlain by oil shale yielding 25 gal or more of oil per ton in beds 15 ft or more thick	890,000	603,000
Areas underlain by oil shale of lesser or unevaluated resource potential	449,000	422,000
Unfavorable areas ²	65,147,000	23,714,000
Total	66,486,000	24,739,000
Aluminum:		
Areas underlain by rocks containing identified aluminum resources	291,000	252,000
Unfavorable areas ²	66,195,000	24,487,000
Total	66,486,000	24,739,000

¹Excludes acreage of more favorable areas on preceding line.²Remainder of State, by difference.

Table 7.—Favorability of Federal land for selected metallic and nonmetallic minerals

Favorability category	acres ¹	%
Known deposits and productive areas	478,000	1.9
Favorable areas ²	4,742,000	19.2
Subtotal	5,220,000	21.1
Less favorable or unknown areas	19,519,000	78.9
Total	24,739,000	100.0

¹Rounded.²Excludes acreage of more favorable areas on preceding line.

PETROLEUM AND NATURAL GAS

About 32,669,000 acres or 49.1% of Colorado, including oil and/or gas fields and adjacent areas of sedimentary rocks, is considered favorable for oil and gas; an additional 23,874,000 acres or 35.9% of the State is rated permissible (table 6). In general, only the geologically old Precambrian core of the mountain province, where sedimentary rocks are thin or absent, is unfavorable. About 7,023,000 acres or 21.5% of the favorable area and 9,901,000 acres or 41.5% of the permissible area are Federal land. West of the Great Plains Province, in the sedimentary basins and adjacent areas, BLM land and, to a lesser degree, FS land compose a substantial part of the areas favorable or permissible for oil and gas (plate 3).

Tables 11 and 12 show the favorability of Federal land for oil and gas and the comparison of Federal land availability and oil and gas favorability. About 28.4% of the Federal land is in the favorable area, and 40.0% is in the permissible area. Of the Federal land in the favorable category, 85.3% is available and 14.7% is unavailable or severely restricted. In the permissible category, 65.8% of the Federal land is available and 34.2% is unavailable or severely restricted.

Legal restrictions account for 25.8% of the unavailable or severely restricted Federal land in favorable areas, and management restrictions account for 74.2%. In the permissible areas, 33.4% of the unavailable or severely restricted Federal land is legally restricted and 66.6% is management restricted.

In addition, Federal lands rated favorable or permissible for oil and gas are subject to slight to moderate restrictions, mostly in the form of seasonal restrictions on surface occupancy. About 4.28 million acres subject to such restrictions were identified; most are in favorable or permissible areas, but the percentage in each category was not determined.

Table 8.—Comparisons of availability of Federal land and favorability for selected metallic and nonmetallic minerals

Availability category	Favorability category						Total Federal land	
	Known deposits and productive areas		Favorable areas		Less favorable or unknown areas		Federal land	
	acres ¹	%	acres ¹	%	acres ¹	%	acres ¹	%
Available ²	404,000	84.5	3,685,000	77.7	13,931,000	71.4	18,020,000	72.8
Unavailable or severely restricted:								
Legal	44,000	NAP	782,000	NAP	3,650,000	NAP	4,476,000	NAP
Management	30,000	NAP	275,000	NAP	1,938,000	NAP	2,243,000	NAP
Subtotal	74,000	15.5	1,057,000	22.3	5,588,000	28.6	6,719,000	27.2
Total	478,000	100.0	4,742,000	100.0	19,519,000	100.0	24,739,000	100.0

NAP Not applicable.

¹Rounded.²Includes slight to moderate restrictions.

Table 9.—Favorability of Federal land for uranium

Favorability category	acres ¹	%
Known deposits and productive areas	171,000	0.7
Favorable areas ²	2,454,000	9.9
Subtotal	2,625,000	10.6
Unfavorable and unevaluated areas	22,114,000	89.4
Total	24,739,000	100.0

¹Rounded.²Excludes acreage of more favorable areas on preceding line.

Table 10.—Comparisons of availability of Federal land and favorability for uranium

Availability category	Favorability category						Total Federal land	
	Known deposits and productive areas		Favorable areas		Unfavorable and unevaluated areas			
	acres ¹	%	acres ¹	%	acres ¹	%	acres ¹	%
Available ²	153,000	89.5	1,748,000	71.2	16,119,000	72.9	18,020,000	72.8
Unavailable or severely restricted:								
Legal	12,000	NAP	454,000	NAP	4,010,000	NAP	4,476,000	NAP
Management	6,000	NAP	252,000	NAP	1,985,000	NAP	2,243,000	NAP
Subtotal	18,000	10.5	706,000	28.8	5,995,000	27.1	6,719,000	27.2
Total	171,000	100.0	2,454,000	100.0	22,114,000	100.0	24,739,000	100.0

NAP Not applicable.

¹Rounded.²Includes slight to moderate restrictions.

Table 11.—Favorability of Federal land for oil and gas

Favorability category	acres ¹	%
Oil and/or gas fields and adjacent areas of sedimentary rocks	7,023,000	28.4
Permissible areas ²	9,901,000	40.0
Subtotal	16,924,000	68.4
Unfavorable areas	7,815,000	31.6
Total	24,739,000	100.0

¹Rounded.²Excludes acreage of more favorable areas on preceding line.

Table 12.—Comparisons of availability of Federal land and favorability for oil and gas

Availability category	Favorability category						Total Federal land	
	Oil and/or gas fields and adjacent areas of sedimentary rocks		Permissible areas		Unfavorable areas			
	acres ¹	%	acres ¹	%	acres ¹	%	acres ¹	%
Available ²	5,990,000	85.3	6,517,000	85.8	4,879,000	62.5	17,386,000	70.3
Unavailable or severely restricted:								
Legal	266,000	NAP	1,129,000	NAP	1,826,000	NAP	3,221,000	NAP
Management	767,000	NAP	2,255,000	NAP	1,110,000	NAP	4,132,000	NAP
Subtotal	1,033,000	14.7	3,384,000	34.2	2,936,000	37.5	7,353,000	29.7
Total	7,023,000	100.0	9,901,000	100.0	7,815,000	100.0	24,739,000	100.0

NAP Not applicable.

¹Rounded.²Includes slight to moderate restrictions.

COAL

About 18,549,000 acres or 27.9% of Colorado is underlain by rocks that are known to generally contain coal (table 6). These favorable areas mostly occur in the Great Plains and Colorado Plateau Provinces, but some occur in the Southern Rocky Mountain-Wyoming Basin Provinces. About 6,309,000 acres or 34.0% of these favorable areas is Federal land (table 6). The western part of the State, Federal land, predominantly BLM land, composes a

substantial part of the North Park, Green River, Uinta, and San Juan River coal regions (plate 4).

As of July 1, 1984, all Federal land in Colorado is subject to a moratorium on coal leasing pursuant to the Fiscal Year 1984 Interior Appropriations, Public Law 98-146. Thus, all Federal land not already leased for coal is legally unavailable until the moratorium is removed.

The Surface Mining Control and Reclamation Act of 1977 directs the Secretary of the Interior to review all Federal land for suitability for coal mining. Under Federal

regulations in 43 CFR 1601.7-1 and 43 CFR 3461, Federal land will be assessed against 20 unsuitability criteria (appendix E). Presently, these criteria have been applied only to small areas of Federal land in known recoverable coal resource areas (KRCRA) or other areas in lease applications.

No statewide determination of suitability of Federal land for coal leasing has yet been made. To show what Federal land might be available for coal leasing at some future date, availability data developed for oil and gas leasing are used on the coal map (plate 4). Some of the restricted areas are known to be closed to all leasing, while others are presently closed only to oil and gas leasing; however, these latter areas also could be closed to coal leasing after the moratorium is removed. Additional areas of Federal land may be restricted when the unsuitability criteria are applied.

OIL SHALE AND ALUMINUM

About 1,339,000 acres of 2.0% of Colorado is underlain by oil shale (table 6); these favorable areas are in the northwestern part of the State (plate 5). About 1,025,000 acres or 76.5% of the favorable areas is Federal land; most is BLM land although part is Naval Oil Shale Reserve and FS land.

Oil shale would be leased only under the 1980 Prototype Oil Shale Leasing Program or such permanent leasing program as may be adopted for oil shale. Presently, eight tracts have been identified for lease by BLM. Two 5,000-acre units, C-a and C-b, were leased in 1974. As of July 1, 1984, however, the Secretary of the Interior had made no decision to offer any additional tracts for oil shale leasing. Thus, all Federal land in Colorado not already under lease is unavailable by management practice.

Aluminum deposits shown on the map (plate 5) are leasable because they contain sodium or potassium minerals. Leasing of sodium deposits in northwestern Colorado alone is not likely because these deposits are associated with oil shale. Potassium deposits in southwestern Colorado are presently leasable. About 291,000 acres or 0.4% of Colorado is underlain by known aluminum deposits (table 6); 252,000 acres or 86.6% of these favorable areas is Federal land.

To show what Federal land might be available for oil shale or aluminum leasing at some future date, availability data developed for oil and gas leasing are used on plate 5. Some of the restricted areas are known to be closed to all leasing, while others are presently closed only to oil and gas leasing; however, these latter areas also could be closed to leasing for oil shale and aluminum in the future.

SUMMARY

Colorado has 24.7 million acres of Federal land (37.2% of the State), mostly in the western two-thirds of the State. Availability of this land for mineral exploration and development will be important because much of it is favorable for mineral deposits.

About 77.4% of the known deposits and productive areas and favorable areas for selected metallic and nonmetallic minerals is Federal land (plate 1). This Federal land (5.22 million acres) is 78.3% available and 21.7% unavailable or severely restricted for mineral exploration and development.

About 34.3% of the known deposits and productive areas and favorable areas for uranium is Federal land (plate 2). This Federal land (2.63 million acres) is 72.4% available and 27.6% unavailable or severely restricted. About 72.6% of the known deposits and productive areas and favorable areas for vanadium is on Federal land, but availability of this land (0.87 million acres) was not determined separately from availability of areas favorable for uranium.

About 21.5% of the known oil and gas fields and adjacent areas of sedimentary rock and 41.5% of permissible areas for oil and gas are Federal land (plate 3). This Federal land (16.92 million acres) is 73.9% available and 26.1% unavailable or severely restricted.

About 34.0% of the favorable areas for coal is Federal land (plate 4). As of July 1, 1984, all federal land not already leased is unavailable, subject to a moratorium on coal leasing.

About 76.5% of the favorable areas for oil shale is Federal land (plate 5). As of July 1, 1984, all Federal land not already leased is unavailable, pending a decision by the Secretary of the Interior to issue such leases under the 1980

Prototype Oil Shale Leasing Program. About 86.6% of the favorable areas for aluminum is Federal land. Most would be leased only in conjunction with oil shale, but four small areas are available for leasing.

For locatable minerals, 66.6% of the unavailable or severely restricted land is the result of legal restrictions and 33.4% is the result of management restrictions. For oil and gas leasing, 43.8% of the unavailable or severely restricted land is the result of legal restrictions and 56.2% is the result of management restrictions.

To the extent that unavailable or severely restricted Federal land overlaps favorable areas, mineral deposits in those areas are regarded as unavailable. Conclusions about the effect of overlap are difficult to quantify, however, because mineral deposits may not be evenly distributed throughout the favorable areas.

Even the Federal land that is available for mineral exploration and development may be subject to some restrictions. Federal land managers have considerable discretionary authority over mineral activities on the land they manage. This control, pursuant to Federal laws and regulations to protect other resources and the environment, affects both leasable and locatable minerals. BLM and FS make use of lease stipulations to regulate leasable mineral activities, and both agencies have regulations to govern locatable mineral activities. In many instances, mineral activities would be regulated on a case-by-case basis. While this style of management allows the land manager flexibility to respond to specific situations, frequently it is not possible to determine the extent of restrictions until leases or permits are requested or mineral activity begins.

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APPENDIX A.—GLOSSARY

Acquired land.—Land in Federal ownership that was obtained by the Government through purchase, condemnation, or gift, or by exchange for such purchased, condemned, or donated lands, or for timber on such land. Federal land that is not public domain land.

Area of critical environmental concern (ACEC).—An area where special management attention is required to protect and prevent irreparable damage to important historic, cultural, or scenic values, fish and wildlife resources, or other natural systems or processes, or to protect life and safety from natural hazards.

Classification.—The designation of lands as being valuable or suitable for specific purposes, uses, or resources. (See segregation.)

Critical and strategic mineral.—A mineral commodity that is essential for a strong national economy and defense but is not produced in the United States in sufficient quantity to meet such needs.

Critical habitat.—Habitat that is essential for the survival of a threatened or endangered species. Designated and protected pursuant to the Endangered Species Act of 1973, as amended.

Critical range.—Range on which a species depends for survival; there are no alternative ranges available because of climatic conditions or other limiting factors. May also be called key range or crucial range.

De facto withdrawal.—Closure of Federal land to mining and/or mineral leasing, or restrictions on such activities by methods other than formal withdrawal. Includes segregating applications, notices of realty action, lands acquired or purchased but not opened, and Bureau of Land Management (BLM) land classifications. One category of management restriction.

Federal land.—Land owned by the United States, without reference to how the land was acquired or what Federal agency administers the land, but excluding lands held by the United States in trust for Indians, Aleuts, or Eskimos. Also in this study, excludes Federal mineral estate under non-Federal surface.

Giant oil or gas field.—Field containing recoverable quantities in excess of 100 million bbl oil or 1 trillion ft³ gas.

Known geologic structure (KGS).—A trap in which an accumulation of oil or gas has been discovered by drilling and which is determined to be productive, the limits of which include all acreage that is presumptively productive. If lands are underlain by a KGS, they may be leased only through a competitive system.

Known recoverable coal resource area (KRCRA).—An area including Federal lands that met minimum standards for recoverable coal deposits in accordance with accepted mining practices, as determined by the Director of the U.S. Geological Survey (USGS). Responsibility for these determinations is now with BLM. No modifications of existing determinations are planned for the present. Land need not be in a KRCRA in order to be leased.

Lease.—A Federal lease, issued under provisions of the mineral leasing laws, which grants an exclusive right to explore for and extract the mineral leased.

Leasable minerals.—Minerals such as coal, oil shale, oil and gas, phosphate, potash, sodium, geothermal resources, and other minerals that may be obtained under the Mineral Leasing Act of 1920, as amended.

Legal restriction.—Closure of Federal land to mining

and/or mineral leasing, or restraints on mineral exploration and development, by statute (law), executive, secretarial, or public land order, or other formal method.

Locatable minerals.—Whatever are recognized as minerals by the standard authorities, whether metallic or other substance, when found in public lands in quantity and quality sufficient to render the lands valuable on account thereof. Minerals that may be obtained under the General Mining Law of 1872, as amended. Excludes minerals specifically designated as leasable or salable minerals.

Management restriction.—Closure of Federal land to mining and/or mineral leasing, or restraints on mineral exploration and development, by agency policy, management decision, regulation, or other discretionary method.

Mineral.—Inorganic and certain organic substances occurring naturally, with characteristics and economic uses that bring them within the purview of mineral laws; a substance that may be obtained under applicable laws from Federal land by purchase, lease or mining claim.

Mineral deposit.—A mass of naturally occurring minerals that may or may not have economic value.

Mineral exploration and development.—The sequence of activities that includes search for and acquisition of mineral deposits, the study and work necessary to determine if such deposits are feasible to mine, and the preparation, if warranted, of a deposit for production (extraction). These activities generally will not be undertaken by private companies or by individuals without a reasonable expectation that they could produce at a profit any valuable deposit that might be discovered.

Mineral materials.—Minerals such as common varieties of sand, stone, gravel, cinders, pumice, pumicite, and clay that are not obtainable under the mining or leasing laws but that can be obtained under the Materials Act of 1947, as amended. These are the salable minerals.

Mining district.—Originally indicating a local government entity established by the miners, the term is now used to designate a geographic area where related metalliferous (usually) mineral deposits occur.

Multiple use.—The management of public lands and their various resource values so that they are utilized in the combination that will best meet the present and future needs of the American people.

Outstanding natural area.—Area of outstanding scenic splendor, natural wonder, or scientific importance that merits special attention and care in management to ensure its preservation in its natural condition.

Permissible.—A category of favorability applied to geographic regions not presently productive of oil and gas, where sedimentary rocks that are capable of holding oil or gas deposits are known or believed to exist.

Primitive area.—Extensive natural, wild, and undeveloped area or setting essentially removed from the effects of civilization.

Priority use area (emphasis area).—Area where a particular resource, such as a wildlife habitat, would receive management emphasis or priority. The areas are either unique, significant, or best suited for the development, management, use, or protection of a particular resource. The principles of multiple use and sustained yield usually would be maintained in each priority use area. Many different uses would be allowed in each priority area, but the priority use would have the first priority. Other land uses would have

limits placed on them to prevent conflicts with the priority resource. In some instances, a use totally incompatible with the priority resource would be excluded.

Public domain land.—Original public domain land that has never left Federal ownership; also land in Federal ownership that was obtained by the Government in exchange for public domain land or for the timber on public domain land. One category of Federal land. (Compare *acquired land*.)

Public land.—Any land and interest in land owned by the United States within the several States and administered by the Secretary of the Interior through BLM, without regard to how the United States acquired ownership, except (1) lands located on the Outer Continental Shelf and (2) lands held for the benefit of Indians, Aleuts, and Eskimos. Includes public domain and acquired lands.

Recreation lands.—A tract of public lands (usually several thousand acres in size) on which outdoor recreation or wildlife has been determined to be the primary use. Recreation lands may have facilities for intensive recreation use or they may remain in a relatively undeveloped condition for extensive forms of use. Where wilderness values predominate, an area may be preserved in a primitive, roadless condition. (See *special recreation management area*.)

Regulations.—Rules promulgated by State and Federal agencies to implement the law and ensure uniform application of the law. Although regulations are not created by the legislature and thus do not have the effect of law, they generally have a statutory authority.

Research natural area.—An area that is established and maintained for the primary purpose of research and education because the land has a threatened or endangered plant or animal species. It is a biological unit where present natural conditions are maintained. These conditions are achieved by allowing natural biological processes to prevail without human intervention.

Reservation.—A withdrawal usually of a permanent nature; also any Federal land that has been dedicated to a specific public purpose. (See *segregation*.)

Reserved land.—Federal land that is dedicated or set aside for a specific public purpose or program and that is, therefore, generally not subject to disposition under the operation of all or some of the public land laws.

Restoration.—An action concurrent with or following a revocation, which effects the opening to disposition of public lands in a withdrawal; also, in respect to ceded Indian lands, an action that returns lands to tribal ownership.

Restriction.—Restrictions of all types on mineral exploration and development on Federal land. In this study, restrictions are classed as legal or management, depending upon the authority or method by which they are effected. All degrees of restraint are included, ranging from normal regulations and standard stipulations to closure of Federal land to mining and/or mineral leasing.

Revocation.—Generally, an action that cancels a previous official act; specifically, an action that cancels a withdrawal.

Salable minerals.—Minerals such as common varieties of sand, stone, gravel, cinders, pumice, pumicite, and clay that may be obtained under the Materials Act of 1947, as amended.

Segregation.—Any action, such as withdrawal, that suspends the operation of all or some of the public land laws, including the mining and mineral leasing laws. A mineral segregation occurs when such an action suspends the operation of the mining or mineral leasing laws for particular Federal land. Three distinct methods of segregation are classification, withdrawal, or reservation.

Severed estate (severed title).—A severed estate results when a title is split into two or more parts. For example, on a particular tract of land, the Federal Government may own the leasable minerals; the State may own all minerals except the leasable minerals; and the surface estate may be in private ownership. Every time a title is transferred, the grantor may retain (reserve) a certain part of the title.

Special recreation management area.—Areas requiring explicit recreation management to achieve the recreation objectives and to provide specific recreation opportunities. Such areas are identified in the resource management plan that also defines the management objectives for the area. Major recreation investments are concentrated in these areas.

Stipulation.—Limiting term or condition in a mineral lease that requires the lessee to meet a specified standard or to follow certain procedures, usually for the protection of other resource values.

Sustained yield.—The achievement and maintenance in perpetuity of a high level of annual or regular periodic output of the various renewable resources of the public lands consistent with multiple use.

Wilderness area.—An area of undeveloped Federal land retaining its primeval character and influence without permanent improvements or human habitation, which is protected and managed to preserve its natural conditions. Includes designated wilderness areas in the National Wilderness Preservation System (NWPS).

Wilderness study area (WSA).—An area designated by a Federal agency or Congress for consideration to be added to the NWPS. The area is managed to preserve wilderness characteristics until it is determined if it should or should not be added to the NWPS. Includes further planning areas and instant study areas.

Withdrawal.—A formal action withholding an area of Federal land from settlement, sale, location, or entry, under some or all of the general land laws, for the purpose of limiting activities under those laws in order to maintain other public values in the area or reserving the area for a particular public purpose or program; also, lands that have been dedicated to public purposes. (See *segregation*.)

APPENDIX B.—AVAILABILITY CATEGORIES AND TYPES OF RESTRICTIONS

All Federal land was classified in this study according to the degree of and authority for restrictions on it. Table B-1 shows how various types of Federal agency land were generally classified as to availability for mineral exploration and development for locatable and leasable minerals. Specific exceptions involving small areas occur in some instances.

Federal land was classed as unavailable or severely restricted if it was closed to mineral location or leasing or if the practical effects of restraints on mineral activity were judged such that mineral exploration or development would be greatly discouraged. Federal land subject to significant restraints on mineral activity beyond standard stipulations (leasing) or surface-protection regulations (location) was classed as slightly to moderately restricted. All other Federal land was classed as available, subject only to restraints from standard leasing stipulations or normal conditions for protection of surface resources.

Legal and management types of restrictions were recognized, and all restricted Federal land was classed as affected by one or the other. Legal authority refers to a closure or restriction to mineral activity as a direct result of a law, executive order, secretarial order, public land order, or other formal method. Management authority includes restrictions stemming from Federal agency

policy, decision, regulation, or other discretionary method.

Some areas are subject to multiple types of restrictions; in such areas the acreage of the most restrictive type appears in the table. The overlapping acreage was subtracted so that all Federal land was counted only once.

Because mineral exploration and development is part of a multiphase cycle, and restrictions on part of the cycle affect the other parts, availability was based on restrictions on any part of the mineral activity cycle: exploration, acquisition, development, production, and reclamation. For example, if land was available for exploration, location, or lease, but subsequent mineral development or production would not be allowed, that land was designated as unavailable or severely restricted. Moreover, conclusions about availability sometimes were extended to other minerals if warranted. Thus, an area withdrawn from mineral location under the mining law for a campground also was presumed to be restricted for leasable minerals, and areas with restrictions on surface occupancy for leasing were presumed to be similarly restricted for locatable minerals.

Locatable minerals in acquired land were considered to be available (by leasing) unless the land was subject to other restrictions.

Table B-1.—General availability of various types of Federal land in Colorado, classified by degree of restriction and authority

Holding agency and type of land	Available	Moderately to slightly restricted		Unavailable or severely restricted	
		Legal	Management	Legal	Management
Department of Agriculture:					
Agricultural Research Service: Experimental Range					Loc, Lse
Forest Service:					
Administrative site				Loc	Lse
Big-game winter habitat			Loc, Lse		
Campground				Loc	Lse
Experimental forest				Loc	Lse
Land utilization project	Loc, Lse				
National forest	Loc, Lse				
National grassland	Loc, Lse				
National recreation area			Loc, Lse		
No lease or no surface occupancy			Loc		Lse
Picnic area				Loc	Lse
Ranger station				Loc	Lse
Recreation site				Loc	Lse
Research natural area				Loc	Lse
Roadside zone				Loc	Lse
Seasonal no surface occupancy			Loc, Lse		
Water supply				Loc, Lse	
Wild and scenic river (proposed)				Loc, Lse	Loc, Lse
Wilderness area				Loc	
Wilderness study area					Loc, Lse
Winter sports area					Loc, Lse
Department of Defense:					
Army Corps of Engineers: Civil works project					Loc, Lse
Department of the Air Force: Military reserve				Loc, Lse	
Department of the Army: Military reserve				Loc	Loc, Lse
Department of Energy:					
Atomic energy withdrawal	Lse			Loc	Loc, Lse
Federal Energy Regulatory Commission:					
Federal power withdrawal				Loc	Lse
Powersite classification		Loc, Lse			
Powersite reserve		Loc, Lse			
Naval Oil Shale Reserve				Loc, Lse	
Department of the Interior:					
Bureau of Land Management:					
Acquired land ¹	Loc, Lse				
Archaeological and historic sites			Lse	Loc	Lse
Area of critical environmental concern			Loc, Lse		
Classification and Multiple Use Act classification	Lse			Loc	
Coal withdrawal	Loc, Lse			Loc ²	
No lease or no surface occupancy			Loc		Lse
Notice of reality action				Loc	
Oil shale withdrawal	Lse			Loc	
Outstanding natural area				Loc	Lse
Protective withdrawal			Lse	Loc	Lse
Public domain land, vacant	Loc, Lse				
Public water reserve	Loc, Lse			Loc ²	
Recreation and public purpose classification			Lse	Loc	
Research natural area				Loc	Lse
Seasonal no surface occupancy			Loc, Lse		
Segregating applications					Loc, Lse
Small tracts			Lse	Loc	
Special recreation management area			Loc, Lse		
Townsite				Loc	Lse
Wild and scenic river (proposed)					Loc, Lse
Wilderness study area					Loc, Lse
Bureau of Reclamation: Reclamation withdrawal			Loc, Lse	Loc	
Fish and Wildlife Service:					
Coordination area				Loc	Lse
National fish hatchery				Loc	Loc, Lse
National wildlife refuge				Loc	Loc, Lse
Geological Survey: Reservoir site				Loc	
National Park Service:					
National park, monument, and historic site				Loc, Lse	
National recreation area				Loc	Lse
Department of Transportation: Federal Aviation					
Administration: Air navigation facility				Loc	
General Services Administration: Radio relay site				Loc	
Veterans Administration: Administration site				Loc, Lse	

Loc Locatable minerals. Lse Leasable minerals.

¹Locatable minerals available by lease.²Nonmetallic minerals.

APPENDIX C.—AVAILABILITY OF INDIAN LAND

Two Indian reservations, the Southern Ute and the Ute Mountain, are located in southwestern Colorado. Land ownership within the boundaries of these reservations is mixed. Much of the land is privately owned, but 902,897 acres is held in trust by the Federal Government for the two tribes. The status of this land is unique. Unlike Federal land, which is administered by various agencies of the Federal Government for the benefit of the people of the United States, Indian trust land is administered by the

Bureau of Indian Affairs (BIA) for the benefit of a particular tribe or allottee.

The availability of Indian trust land for mineral exploration and development is not determined in the same manner as it is for Federal land. In general, trust land is available for exploration and development through leases negotiated with the appropriate tribal council. Such leases are reviewed and approved by the BIA.

APPENDIX D.—MAJOR FEDERAL LAWS AFFECTING MINERAL EXPLORATION AND DEVELOPMENT

Act of March 3, 1807 (2 Stat. 448).—First mineral land leasing act, reserved lead mines and adjacent areas to Federal Government for future disposal, and provided for their lease to private parties for a limited term. Later related acts reserved other minerals in certain States from sale and/or provided for leasing. Most Federal mineral lands were available by leasing from 1807 to 1846.

Act of April 25, 1812 (2 Stat. 716).—General Land Office was organized as a bureau in Treasury Department. It was transferred in 1849 to Department of the Interior (DOI) and abolished in 1946 when its functions were transferred to new Bureau of Land Management (BLM). Responsible for public land laws relating to surveys, disposal, and other activities concerning administration and management of the public land.

Act of July 11, 1846 (9 Stat. 37).—Authorized sale of lead mines in the Upper Mississippi Valley and in Arkansas at public auction at \$2.50/acre. Other related acts provided for survey and sale of mineral land in various States, and authorized preemptive rights to mineral land. Period of Federal mineral land sales extended from 1846 to 1866. Some mineral land was sold under the agricultural laws, for various reasons.

Act of May 20, 1862 (12 Stat. 392).—*Homestead Act of 1862.*—This and later homestead acts allowed settlers to enter nonmineral public land for agricultural purposes, meet certain conditions for improvements, and obtain a patent (title) to the land, including the minerals, in most cases. Many of these lands have subsequently yielded substantial mineral deposits.

Act of July 26, 1866 (14 Stat. 251).—*Mining Act of 1866.*—All mineral lands of the public domain were declared open to exploration and occupation. The act provided for location of lode mining claims, and upon expenditure of at least \$1000 in improvements, a patent could be purchased at the rate of \$5.00/acre. The law allowed only one location per lode and limited each location to 200 ft along the lode or vein.

Act of July 9, 1870 (16 Stat. 217).—*Placer Claims Act of 1870.*—This act amended the Act of July 26, 1866, to include placer locations. It allowed placer claims to conform to legal subdivision on surveyed lands. Placer claims could not exceed 160 acres for any one person or association of persons. Payment for patent of placer claims was set at the rate of \$2.50/acre.

Act of May 10, 1872 (17 Stat. 91).—*General Mining Law of 1872.*—This well-known act replaced much of the 1866 and 1870 laws. It declared "all valuable mineral deposits in lands belonging to the United States . . . to be free and open to exploration and purchase." It authorized placer and lode mining claims to be located by a procedure that is largely unchanged to this day. The act also requires that not less than \$100 worth of work be performed on each claim per year. Patents may be issued for lands containing "valuable deposits" upon expenditure of \$500 worth of work. Later acts excluded claims in several States and specifically included various minerals available under the mining laws. The 1872 act remains the method for disposal of minerals in Federal land that are not specifically provided for in later mineral leasing and sales laws.

Act of March 3, 1877 (19 Stat. 377).—*Desert Land En-*

tries Act.—Provided for entry and disposal of arid land, non-mineral in character; if conditions for improvement are met, patent to the land, including the minerals, may be obtained.

Act of March 3, 1879 (20 Stat. 394).—*Geological Survey Organic Act.*—U.S. Geological Survey (USGS) was established and authorized to study the geologic structure, mineral resources, and products of the national domain, and to classify the public lands.

Act of June 4, 1897 (30 Stat. 34).—*National Forest System Organic Act of 1897.*—Provided for administration and management of the national forest reserves established by Presidential proclamation under the Act of March 3, 1891, to improve and protect the forest, and secure favorable conditions for waterflows and a supply of timber. Administration transferred from DOI to Agriculture Department in 1905. Vacant unappropriated Federal land in the National Forest System (NFS) is generally open to entry under the mining and mineral leasing laws, subject to rules and regulations governing the forest. The first major closure of public lands to disposal under nonmineral, but not mineral, land laws.

Act of June 17, 1902 (32 Stat. 388).—*Reclamation Act of 1902.*—Authorized withdrawal of land for irrigation projects and of all land believed to be susceptible to irrigation from such projects. The land was segregated from operation of the mining laws, but has been open to mineral leasing, with restrictions, since 1920. In addition, the Act of October 2, 1898, as amended, effected an automatic withdrawal of all land actually designated or selected for reservoirs, ditches, or canals for irrigation purposes, unless otherwise provided by law.

Act of June 8, 1906 (34 Stat. 225).—*Antiquities Act of 1906.*—Provided for protection of cultural resources on Federal land, specified penalties for violations, and authorized the President to proclaim lands containing historic landmarks, historic and prehistoric structures, and other objects of historic or scientific interest as national monuments; such areas were reserved from operation of the mining and mineral leasing laws, unless specifically provided otherwise.

Act of March 3, 1909 (35 Stat. 844).—This and several later acts, including the Act of July 17, 1914, permitted the separation of surface and mineral ownership (severed estates), allowed agricultural entries on land withdrawn or classified as valuable for minerals, but reserved the minerals, primarily fossil fuels and fertilizer minerals, for which the land was considered valuable, to the United States. Severed estates created a later problem in management of public lands.

Act of May 16, 1910 (36 Stat. 369).—*Bureau of Mines Organic Act.*—Bureau of Mines was established with duties covering health and safety, conservation, research, and prevention of waste in the mineral industries.

Act of June 25, 1910 (36 Stat. 847).—*General Withdrawal Act (Pickett Act).*—Passed in response to controversy about large withdrawals made under implied Executive authority, the act, as amended by the Act of August 24, 1912, authorized the President to withdraw public land temporarily, for various public purposes; the withdrawn land specifically remained open under the mining laws to metalliferous minerals. This authority was delegated to the

Secretary of the Interior in 1942, who now exercises it for all Federal agencies with their approval on land in their jurisdiction. Withdrawal of metalliferous minerals from location continued, apart from the Pickett Act, under implied Executive authority.

Act of August 25, 1916 (39 Stat. 535)—National Park Service Organic Act.—Established the National Park Service (NPS) to administer existing and future national parks and monuments "to conserve the scenery and the natural and historic objects and the wildlife therein to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations." Most units of the National Park System are specifically withdrawn from all mineral development.

Act of December 29, 1916 (39 Stat. 863)—Stockraising Homestead Act of 1916.—Authorized entries on the public land for stockraising (grazing) purposes, but unlike earlier homestead acts, reserved all minerals to the United States whether or not the land was considered to be valuable for any mineral. Federal minerals in these lands are open to location and patent under the general mining laws and to leasing under the mineral leasing laws. Added to the problem of management of severed surface and mineral estates.

Act of February 25, 1920 (41 Stat. 437)—Mineral Leasing Act of 1920.—Removed deposits of coal, phosphate, sodium, oil, oil shale, and gas from disposal under the mining laws, and made such deposits subject to a leasing system. The law specifies rental and royalty rates, lease size, and term for each leasable mineral, and it provides for prospecting permits and competitive bidding for certain deposits. Allows the Secretary of the Interior broad discretion in granting permits and leases. Although later amended to include other minerals and change certain requirements, the act remains the method of disposal of these minerals.

Act of June 10, 1920 (41 Stat. 1063)—Federal Water Power Act.—Section 24 of the act provided that filing an application for a permit or license for a powersite automatically withdraws the land from all forms of disposal; classification of land as valuable for powersite purposes by USGS also effects a withdrawal under the act. Such withdrawals were opened, with restrictions, by the Mining Claims Rights Restoration Act of August 11, 1955.

Act of June 14, 1926 (44 Stat. 741)—Recreation and Public Purposes Act.—Provided for reservation of public land chiefly valuable for recreational purposes, and for the lease, exchange, or sale of such land to State and local governments. Minerals in such lands are reserved to the United States and are unavailable under the general mining laws.

Act of December 22, 1928 (45 Stat. 1069)—Color of Title Act.—Authorized the issuance of patents for public land erroneously held for a specified period in good faith. The minerals may be reserved to the United States or included in the patent.

Act of April 23, 1932 (47 Stat. 136).—Authorized the Secretary of the Interior, at his discretion, to open public land withdrawn for reclamation purposes, upon application, to location and patent under the mining laws, subject to some restrictions.

Act of June 28, 1934 (48 Stat. 1269)—Taylor Grazing Act of 1934.—Marking the end of Federal policy of disposal of nonmineral public land, the Act provided for management of all unreserved public land, except in Alaska, withdrawal of all vacant public land for classification (but not from entry

under the mining laws), and establishment of grazing districts and the Grazing Service.

Act of July 22, 1937 (50 Stat. 525)—Bankhead-Jones Farm Tenant Act.—Authorized Federal acquisition of privately owned submarginal farmland; the land, known as land utilization project (LUP) land, constitutes most of the national grassland in Colorado.

Act of June 1, 1938 (52 Stat. 609)—Small Tract Act.—Permitted the lease or sale of tracts of public land of 5 acres or less that were valuable for recreational, home, or business site purposes. All minerals were reserved to the United States and were unavailable under the general mining laws. Classification of land for small tract disposal segregated the land from location under the mining laws. Repealed by the Federal Land Policy and Management Act of 1976 (FLPMA).

Act of June 7, 1939 (53 Stat. 811)—Strategic and Critical Materials Stockpiling Act.—Authorized the President to stockpile strategic and critical minerals, and the Secretary of the Interior to investigate and develop new sources of such minerals.

Reorganization Plan No. 3 of 1946 (60 Stat. 1097).—Authorized the Secretary of the Interior to lease, with the concurrence of the Secretary of Agriculture, those Federal minerals in acquired national forest and grassland that, on public land, are subject to location and disposition under the general mining laws. Also, established BLM with combined functions of the General Land Office and the Grazing Service.

Act of July 31, 1947 (61 Stat. 681)—Materials Act of 1947 (Public Law 291).—Authorized disposal of certain materials, including sand, stone, gravel, and common clay, on public land by sale, if not otherwise expressly authorized or prohibited by law. Free use of such materials was permitted for noncommercial use by government and nonprofit agencies.

Act of August 7, 1947 (61 Stat. 913)—Mineral Leasing Act for Acquired Lands (Public Law 382).—Authorized the Secretary of the Interior to lease those minerals in all acquired land that are leasable in public land under the Mineral Leasing Act of 1920, subject to concurrence of the surface management agency.

Act of August 13, 1954 (68 Stat. 708)—Multiple Mineral Development Act of 1954 (Public Law 585).—Amended the mining and mineral leasing laws to permit multiple development of both locatable and leasable minerals on the same tract of land. If a mineral patent is issued, the leasable minerals are reserved to the United States with the right to recover such minerals. The related Act of August 12, 1953, validated certain mining claims located between 1939 and 1953 on land under a prospecting permit or mineral lease.

Act of August 30, 1954 (68 Stat. 919)—Atomic Energy Act of 1954 (Public Law 703).—Authorized the Atomic Energy Commission, and now the Department of Energy, to issue leases for exploration and mining of fissionable materials on Federal land.

Act of July 23, 1955 (69 Stat. 367)—Surface Resources Act of 1955 (Public Law 167).—Defined common varieties of sand, stone, gravel, pumice, pumicite, cinders, and clay, and excluded such mineral materials from location under the mining law; they are salable under the Materials Act of 1947. Also, authorized the Government to manage and dispose of the land and surface resources that are not incident to mining on unpatented mining claims.

Act of August 11, 1955 (69 Stat. 679)—Uraniferous

Lignite Act of 1955 (Public Law 357).—Permitted location of mining claims for uranium and other fissionable source materials on public land classified or known to be valuable for lignite coal.

Act of August 11, 1955 (69 Stat. 681)—Mining Claims Rights Restoration Act of 1955 (Public Law 359).—Provided for location of mining claims on land withdrawn or reserved for power development. Mineral development is liable to risk from any future power development. Location of placer claims is subject to additional requirements, and placer mining may be denied by the Secretary of the Interior if such operation would substantially interfere with other uses of the land.

Act of July 20, 1956 (70 Stat. 592).—Proved that any reserved mineral deposit located prior to the Mineral Leasing Act of 1920 is subject to disposal by mineral patent.

Act of August 8, 1956 (70 Stat. 1119)—Fish and Wildlife Act of 1956 (Public Law 1024).—Established the Fish and Wildlife Service in the Department of the Interior, and, as amended, authorized the Secretary to take such steps as may be required for development, advancement, management, conservation, and protection of fish and wildlife resources. In addition, the National Wildlife Refuge System Administration Act (Public Law 89-669; 80 Stat. 926) authorized the Secretary to permit uses of these lands, provided such uses are compatible with the purposes for which such areas were established.

Act of February 28, 1958 (72 Stat. 27)—Defense Withdrawal Act of 1958.—Withdrawals or reservations aggregating more than 5,000 acres for any one defense project or facility can only be made by Act of Congress. Minerals on all withdrawals or reservations for the Department of Defense are subject to disposition under the mining and mineral leasing laws, except where the Secretary of Defense, after consultation with the Secretary of the Interior, determines that such disposition is inconsistent with military use of the land.

Act of August 21, 1958 (72 Stat. 700).—Authorized the Secretary of the Interior to develop a program to encourage exploration for mineral reserves by private industry.

Act of March 18, 1960 (74 Stat. 7)—Placer Claims Millsite Act of 1960 (Public Law 86-390).—Provided for location and patent of up to 5 acres of nonmineral land in connection with a placer mining claim.

Act of June 12, 1960 (74 Stat. 215)—Multiple-Use, Sustained-Yield Act of 1960 (Public Law 86-517).—Directed the Secretary of Agriculture to develop and administer the renewable surface resources of the national forests for multiple use and sustained yield, giving due consideration to the relative values of the various resources in particular areas. Wilderness areas are consistent with the act; the act does not affect the use or administration of the mineral resources of national forest lands.

Act of October 23, 1962 (76 Stat. 1127)—Mining Claim Occupancy Act of 1962.—Authorized the Secretary of the Interior to convey up to fee simple title to residential occupants of unpatented mining claims on which valuable improvements have been made.

Act of December 17, 1963 (77 Stat. 392)—Clean Air Act (Public Law 88-206).—Established a national program to control air pollution. Under the act, as amended, standards are set for air quality and attainment status is determined by area. Permits are required for new sources of air pollution, including mining and milling operations.

Act of September 3, 1964 (78 Stat. 890)—Wilderness Act (Public Law 88-577).—Created the National Wilderness

Preservation System (NWPS) and provided for its administration in such manner as will leave it unimpaired for future use and enjoyment as wilderness. All Federal land in the system is closed to operations under the mining and mineral leasing laws, subject to valid existing rights, after 1983. Subsequent acts added considerable Federal land to the system.

Act of September 19, 1964 (78 Stat. 986)—Classification and Multiple Use Act of 1964.—Authorized the Secretary of the Interior to classify and manage BLM land for retention or for disposal, and for multiple use, including specification of dominant uses and preclusion of inconsistent uses in an area. Classification segregated the land from operation of the mining and, in some instances, the mineral leasing laws.

Act of October 15, 1966 (80 Stat. 915)—National Historic Preservation Act of 1966.—Expanded Federal support for historical preservation through the National Register of Historic Places, a list of places protected from destruction by any project involving Federal action. All agencies must review the effect of a project on any district, site, building, structure, or object on the National Register.

As of October 2, 1968 (82 Stat. 906)—Wild and Scenic Rivers Act of 1968 (Public Law 90-542).—Created the Wild and Scenic Rivers System to preserve parts of designated rivers from further development; the system is managed to preserve scenic or other values that justified designation. Minerals in Federal land within 0.25 mile of each bank are withdrawn under the mining and mineral leasing laws. Proposed river corridors are segregated, also, pending study.

Act of January 1, 1970 (83 Stat. 852)—National Environmental Policy Act of 1969 (Public Law 91-190).—Declared a national policy of "productive and enjoyable harmony between man and his environment." Requires a detailed analysis for all "major Federal actions significantly affecting the quality of the human environment." Many activities under the mining and mineral leasing laws are subject to the act; substantial costs have resulted from required environmental studies and mitigation of environmental impacts.

Act of December 24, 1970 (84 Stat. 1566)—Geothermal Steam Act of 1970 (Public Law 91-581).—Authorized the leasing of geothermal resources and associated byproducts in public lands through competitive and noncompetitive leasing systems. The Geothermal Energy Research, Development, and Demonstration Act of 1974 promoted the development and utilization of geothermal resources.

Act of December 31, 1970 (84 Stat. 1876)—Mining and Minerals Policy Act of 1970 (Public Law 91-631).—Declared that the Federal Government policy is to encourage private enterprise in the development of (1) a sound and stable domestic minerals industry, (2) domestic mineral deposits, (3) minerals research, and (4) methods for reclamation in the minerals industry.

Act of October 18, 1972 (86 Stat. 816)—Federal Water Pollution Control Act Amendments of 1972 (Public Law 92-500).—Established a program to control pollution by limiting the amount of effluent that may be discharged into a body of water. Permits are required for the discharge of water from point sources including mining and milling processes. The related Safe Water Drinking Act of 1974, as amended, also requires permits for injection wells for oil and gas operations and for special wells for solution mining, in situ gasification, and recovery of geothermal energy.

Act of December 28, 1973 (87 Stat. 884)—Endangered Species Act of 1973 (Public Law 93-205).—Established a

policy to conserve endangered and threatened species of plants and animals. The act, as amended, provides for determination of such species and designation of their critical habitat, and prohibits any Federal action modifying such critical habitat, unless exempted by a cabinet-level committee. Affects any mining activity requiring Federal action.

Act of August 4, 1976 (90 Stat. 1083)—Federal Coal Leasing Amendments Act of 1976 (Public Law 94-377).—Amended the Mineral Leasing Act of 1920 to change the procedure for leasing coal on Federal land, to provide for fair market value and diligent development on Federal coal leases, to coordinate management of coal and nonmineral resources, and to ensure compatibility of coal mining with land use plans.

Act of September 28, 1976 (90 Stat. 1342)—Mining in the National Parks Act (Public Law 94-429).—Closed certain national parks and monuments to mining, imposed a moratorium on mineral exploration and development, and established additional requirements on mining in national parks and monuments where still allowed.

Act of October 21, 1976 (90 Stat. 2743)—Federal Land Policy and Management Act of 1976 (Public Law 94-579).—The act, also known as the BLM Organic Act, established a comprehensive procedure for the inventory, analysis, planning, and management of BLM land. Repealed most previous public land laws, set up a comprehensive land planning system, controlled withdrawal procedures more closely (and repealed the implied authority of the President to make withdrawals), required recordation of mining claims with BLM, and authorized the Secretary of the Interior to establish a regulatory program to "take any action necessary to prevent unnecessary or undue degradation of the lands."

Act of October 21, 1976 (90 Stat. 2795)—Resource Conservation and Recovery Act of 1976.—Established a Federal program for management of solid waste, prohibited future open dumping, and defined and regulated hazardous waste closely. Some mining waste is excluded, but other mining waste is included. The related Comprehensive Environmental Response, Compensation and Liability Act of 1980 (the Superfund Act) provided that Federal or State Governments may bring claim for any damage to natural resources under their trusteeship caused by release of hazardous substances.

Act of October 22, 1976 (90 Stat. 2949)—National Forest

Management Act of 1976.—The act, which supplements and amends the Forest and Rangeland Renewable Resources Planning Act of 1974, provided a comprehensive framework and prime source of direction to the Forest Service (FS) through required land and resource management planning to achieve effective use of renewable resources and NFS land. Required the Secretary of Agriculture to set planning regulations; standards and guidelines in the regulations must be incorporated into land and resource management plans.

Act of August 3, 1977 (91 Stat. 445)—Surface Mining Control and Reclamation Act of 1977 (Public Law 95-87).—Established the Office of Surface Mining in DOI to administer reclamation of all surface mined coal land. Authorized a fund for abandoned mine reclamation, standards for environmental protection, requirements for reclamation plans, and designation of areas unsuitable for mining.

Act of November 9, 1977 (91 Stat. 1290)—Federal Mine Safety and Health Amendments Act of 1977.—Repealed or amended the previous mine safety and health acts of 1966 and 1969. Created the Mine Safety and Health Administration in the Department of Labor, responsible for enforcement of the mine health and safety laws.

Act of November 8, 1978 (92 Stat. 3021)—Uranium Mill Tailings Radiation Control Act of 1978.—Established a remedial action program for uranium mill tailings at certain inactive sites and a uranium mill tailings license and regulatory program, administered by the Nuclear Regulatory Commission.

Act of October 21, 1980 (94 Stat. 2305)—National Materials and Minerals Policy, Research and Development Act of 1980 (Public Law 96-479).—Reaffirmed a national policy to foster promotion of domestic materials, minerals, and mineral reclamation industry under private enterprise. Among specific points, Federal agencies are encouraged to "facilitate availability and development of domestic resources to meet critical materials needs."

Act of December 22, 1980 (94 Stat. 3265)—Colorado Wilderness Act (Public Law 96-560).—Amended the Wilderness Act of 1964, to add new wilderness areas to the NWPS and designate other wilderness study areas in Colorado. Also released other areas not recommended for wilderness or further study and said they no longer must be managed to protect their wilderness character.

APPENDIX E.—AVAILABILITY OF FEDERAL LAND IN COLORADO BY AGENCY

Whether Federal land is available for mineral exploration and development depends greatly upon the specific mission or purpose of the agency responsible for managing the land. In Colorado, almost 94% of the federally owned land is managed by just two agencies, the Forest Service (FS) and the Bureau of Land Management (BLM). These agencies manage much of this land for multiple uses. All other agencies managing Federal land in the State administer land under their jurisdiction for purposes that generally are not compatible with mineral exploration and development.

FOREST SERVICE

FS administers 14,431,083 acres of National Forest System (NFS) land in Colorado. Included are 13,818,593 acres in 12 national forests, 611,930 acres in 2 national grasslands, and 560 acres in a land utilization project. Data on NFS land was obtained mostly from resource management plans (47).¹ Acreage for each administrative unit is shown in table E-1.

Table E-1.—National Forest System land in Colorado, net acres

Arapaho NF, Roosevelt NF, Pawnee NG	2,006,470
Grand Mesa NF, Uncompahgre NF, Gunnison NF	2,953,235
Manti-La Sal NF ¹	27,105
Pike NF, San Isabel NF, Comanche NG,	
Fountain Creek LUP	2,637,213
Rio Grande NF	1,851,424
Routt NF	1,127,164
San Juan NF	1,867,640
White River NF	1,960,832
Total	14,431,083

LUP Land utilization project.

NF National Forest.

NG National grassland.

¹Acreage in Colorado.

Note: Total differs from that used in table 1 (main text) because different source documents were used.

Source: FS. Land Areas of the National Forest System as of Sept. 30, 1983. P. 17.

Management of Mineral Resources

According to the FS Manual (FSM 2801), "The objective of the FS is to integrate the development and use of mineral resources with the use and conservation of all other forest resources to the fullest extent possible under the laws governing mineral disposal. This embodies the concept of multiple use in its broadest sense."

Generally, NFS land is available for mineral exploration and development under the mining and mineral leasing laws. The NFS Organic Act of 1897, which provided for administration of the national forest, specifically states that these lands shall continue to be open to entry under the General Mining Law of 1872. Presently, certain types of NFS land are unavailable or restricted, however, because of subsequent events.

FS does not allocate or regulate levels of mineral production. Regional goals for minerals management in the Rocky Mountain Region (47) are:

1. Recognize the national importance of NFS land as a source of energy and mineral resources needed for economic growth and security.

2. Facilitate exploration and development of energy and mineral resources on NFS land by avoiding conflicting surface resource uses, to the degree possible, in areas of high to moderate mineral potential by providing a timely response to requests for authorizations to conduct mineral activities.

3. Manage energy and mineral resource activities on NFS land to minimize their effect upon other uses and to conserve other resources consistent with mineral laws and regulations.

FS also has three distinct roles involving mining on NFS land:

1. Make land available for exploration and development of mineral resources.

2. Manage surface use operations to minimize adverse environmental impacts of operations and to ensure proper reclamation of disturbed land.

3. Validate mining claims. (BLM administers mining laws; however, an April 1957 memorandum of understanding between the two agencies provides for joint administration of the mining laws on NFS land.)

The FS regulations pertaining to use of the surface of NFS land in connection with mineral operations are stated in 36 CFR 228. For locatable minerals, the regulations require a notice of intent if operations might cause disturbance of surface resources, and a plan of operations if they are likely to cause significant disturbance of surface resources. Moreover, all operations shall be conducted in a manner to minimize adverse environmental impacts on surface resources. The agency reviews applications for leases and permits, notices of intent, and operating plans submitted by the mineral industry and establishes stipulations to protect surface resources.

The NFS includes 2,585,682 acres of wilderness areas (table E-2) and 661,510 acres of wilderness study areas (table E-3). The Wilderness Act of 1964 closed designated wilderness areas to mineral leasing and location after 1963, subject to valid existing rights. Wilderness study areas are under interim management to protect their wilderness characteristics until final decisions have been made on their suitability as wilderness areas; therefore, these areas are considered to be severely restricted by management decision for mineral exploration and development for locatable and leasable minerals.

Restrictions on Locatable Minerals

Within the NFS in Colorado, 2,946,000 acres are unavailable for locatable minerals by legal methods, and more than 837,000 acres are unavailable or severely restricted by management decision. These areas are predominantly wilderness and wilderness study areas but include smaller amounts of other special-use categories of land. Special-use categories include administrative sites; developed recreation sites; winter-sport sites; areas of geological, cultural, scenic, or botanical interest; experimental forest; municipal watersheds; proposed wild and scenic

¹Italicized numbers in parentheses refer to items in the list of references preceding appendix A.

Table E-2.—Forest Service wilderness areas in Colorado
(National Wilderness Preservation System)

Name of area	National forest(s)	Net acres
Big Blue	Uncompahgre	96,320
Cache La Poudre	Roosevelt	9,238
Collegiate Peak	Gunnison-San Isabel	
	White River	166,654
Cornucopia Peak	Roosevelt	66,791
Eagle Nest	Arapaho-White River	133,325
Flat Tops	Routt-White River	235,035
Holy Cross	San Isabel-White River	122,037
Hunter-Frylingan	White River	74,250
Indian Peaks	Arapaho-Roosevelt	70,374
La Garita	Gunnison-Rio Grande	103,986
Lizard Head	San Juan-Uncompahgre	41,189
Lost Creek	Pike	105,090
Maroon Belle-Snowmass	Gunnison-White River	181,138
Mount Evans	Arapaho-Pike	74,401
Mount Massive	San Isabel	27,980
Mount Sneffels	Uncompahgre	16,505
Mount Zirkel	Routt	139,818
Neota	Roosevelt-Routt	9,924
Never Summer	Arapaho-Routt	13,702
Raggeds	Gunnison-White River	59,519
Rawah	Roosevelt-Routt	73,020
South San Juan	Rio Grande-San Juan	127,690
Weminuche	do	455,604
West Elk	Gunnison	176,092
Total		2,585,682

Sources: FS, Land Areas of the National Forest System as of Sept. 30, 1984. Pp. 67-68.

Table E-3.—Forest Service wilderness study areas and
further planning areas in Colorado

Name of area	National forest(s)	acres
Wilderness study areas:		
Buffalo Peaks	San Isabel	56,950
Fossil Ridge	Gunnison	47,400
Greenhorn Mountain	San Isabel	22,330
Oh-Be-Joyful	Gunnison	5,500
Piedra	San Juan	41,500
Sangre De Cristo	Rio Grande-San Isabel	217,832
South San Juan Expansion	San Juan	32,800
Spanish Peaks	San Isabel	19,570
Spruce Creek	White River	8,000
Vasquez Peak	Arapaho	12,800
West Needle	San Juan	15,800
Wheeler Geologic	Rio Grande	11,390
Total wilderness study areas		491,872
Further planning areas:		
Cannibal Plateau	Gunnison	31,990
Davis Peak	Routt	8,100
Lost Creek	Pike	23,000
Service Creek	Routt	39,860
St. Louis Peak	do	12,800
Williams Fork	Arapaho-Routt	53,886
Total further planning areas		169,636
Grand total		661,510

Source: FS, Region 2 (Lakewood, CO). List of Wilderness, Study, and Planning Areas in Colorado. 1983, 2 pp.

rivers; natural history areas; national historic landmarks; and research natural areas.

In addition, about 3,009,000 acres—big-game winter-habitat areas and other areas that FS has designated “no lease” or “no surface occupancy”—are classed in this study as slightly to moderately restricted owing to management decisions (47), but these areas are shown as available on plates 1 and 2.

Areas not legally closed are administered on a case-by-case basis, under regulations in 36 CFR 228, when mineral exploration and development is planned.

Restrictions on Oil and Gas Leasing

Decisions to lease are made on a case-by-case basis; however, FS management plans (47) call for withholding land from mineral leasing only in exceptional cases. Within the NFS in Colorado, about 2,599,000 acres are legally closed to mineral leasing, and 2,680,000 acres are unavailable or severely restricted by management decision. Legally closed areas include wilderness areas, portions of the Wild and Scenic Rivers System, and a few special-use areas. Areas unavailable or severely restricted by management decision include wilderness study areas and areas designated “no lease” or “no surface occupancy” because of high erosion hazard, high geologic hazard, low visual absorption capacity, or endangered- or threatened-species habitat.

All NFS land is subject to current standard lease stipulations. Regionally approved special stipulations also are applied as needed to protect specific surface resources. In addition to no-surface-occupancy areas, about 1,077,000 acres of NFS land is subject to seasonal restrictions on surface occupancy, for big-game winter habitat. FS will recommend against leasing to BLM where operational damages would be irreversible.

Restrictions on Coal Leasing

Coal mining on NFS land is subject to the prohibitions and unsuitability criteria in the Surface Mining Control and Reclamation Act of 1977 (SMCRA) and the coal regulations (43 CFR 3461). (These criteria are listed in the next section about land managed by BLM, which has the responsibility for federally owned coal.) Briefly, the NFS itself is designated unsuitable, but an exception may be made if there are no significant recreational, timber, economic, or other values incompatible with the lease, and (1) surface operations and impacts are incident to an underground coal mine or (2) the Secretary of Agriculture determines, for land that does not have significant forest cover, that surface mining may be in compliance with the Multiple-Use, Sustained-Yield Act of 1960, the Federal Coal Leasing Amendments Act of 1976, and the SMCRA. In addition, NFS land is unsuitable for all or certain stipulated methods of coal mining involving surface coal mining operations if it includes units of the National Wilderness Preservation System (NWPS), National Wild and Scenic Rivers System, National System of Trails, national recreation areas (NRA), or other land included in the unsuitability criteria.

FS consent to BLM for issuance of coal leases, permits, or coal exploration licenses on other NFS 1 and includes all current standard stipulations and any other stipulations that may be necessary for additional protection of specific surface resources. FS denies consent for issuance of coal leases, permits, or exploration licenses where operational damages to surface resources would be irreversible or irretrievable with no potential for reclamation. Consent denials are based upon the following criteria: a finding of unsuitability according to criteria discussed in the previous paragraph, presence of unstable terrain, inadequate room for waste dumps and tailings, adverse impact on water quality, slopes steeper than 60%, low visual absorption capacity, and presence of threatened or endangered species.

Complete information about the availability of NFS land for coal mining is lacking because the unsuitability criteria have not been applied to all NFS land. Where the criteria have been applied, however, within known

recoverable coal resource areas (KRCRA's) in the national forests, 239,551 acres have been found unsuitable for coal leasing.

BUREAU OF LAND MANAGEMENT

BLM ranks second among the Federal land managers in Colorado, administering 8,346,472 acres of public domain and acquired land. The State is organized into 4 districts and 11 resource areas. In addition to managing public land, BLM has responsibility for minerals management on other Federal land in the State, subject to the recommendation of the agency managing the surface, and for the severed Federal mineral estate under non-Federal surface. Severed Federal mineral ownership, including all or part of the minerals, aggregates almost 5.87 million acres in Colorado; these federally owned minerals are not included in the analysis of Federal land availability nor are they shown on plates 1 through 5.

Land Use Planning

The Federal Land Policy and Management Act of 1976 (FLPMA) is the basic statute that governs BLM planning and management of the Federal land and minerals under its jurisdiction. The act, sometimes called the BLM Organic Act, emphasizes multiple-use management and environmental protection through comprehensive land use planning use planning procedures. The land use planning process involves nine basic steps, resulting in a combined resource management plan and environmental impact statement (RMP/EIS) for one BLM resource area or other area of special interest. Planning actions, under regulations in 43 CFR 1610, include identification of issues, development of planning criteria, inventory of resource data, analysis of the management situation, formulation of alternatives, estimation of effect of alternatives, selection of preferred alternative, preparation of RMP/EIS, and monitoring and evaluation of the plan. Planning is done at local levels, in resource area and district offices. The RMP incorporates decisions allowing permissible combinations or resource uses, while restricting others, based on capabilities of the land. The emphasis is on multiple-use management while preventing undue degradation of the land. Thus, availability of land for mineral exploration and development is a function of many variables. In Colorado, the BLM planning process is under way, but RMP/EIS draft or final documents are available for only a part of the State, including the Glenwood Springs, Kremmling, Northeast, and San Juan Resource Areas and a small part of the Piceance Basin (43).

Management of Mineral Resources

The following principles guide BLM management of mineral resources on BLM land (43):

1. Except for Congressional withdrawals, public land shall remain open and available for mineral exploration and development unless withdrawal or other administrative action is clearly justified in the national interest.

2. BLM actively encourages and facilitates the development by private industry of public land mineral resources so that national and local needs are satisfied and environmentally sound exploration, extraction, and reclamation practices are provided.

3. BLM will process mineral applications, permits, leases, and other use authorizations for public lands in a timely and efficient manner.

4. BLM's land use plans and multiple-use management decisions will recognize that mineral exploration and development can occur concurrently or sequentially with other resource uses. BLM further recognizes that land use planning is a dynamic process and decisions will be updated as new data are evaluated.

Mineral exploration and development activities are managed, pursuant to the mining and mineral leasing laws, under regulations in 43 CFR 3000. Specific parts of these regulations deal with management of certain minerals.

Locatable Minerals

All public domain land is open to mineral entry and location unless legally withdrawn. Mineral activities on public land are regulated under 43 CFR 3800 to prevent unnecessary and undue degradation of the land. Locatable minerals on acquired Federal land are available for lease, subject to the discretion of BLM and to stipulations to protect the environment.

Oil and Gas

As a general rule, public land is available for oil and gas leasing. Within a known geologic structure (KGS), oil or gas are disposed of by leasing through competitive bidding; areas outside a KGS are disposed of by noncompetitive leasing. Activities are regulated under 43 CFR 3100.

Coal

Pursuant to the SMCRA, BLM is required to review areas containing Federal coal to determine which lands are unsuitable for all or certain stipulated methods of coal mining. BLM procedures for assessing unsuitability are defined in the planning regulations (43 CFR 1610.7-1) and in the coal regulations (43 CFR 3461). The 20 criteria addressing unsuitability for the surface mining of coal (exceptions and exemptions are not listed) are to protect

1. All Federal lands included in the following land systems or categories . . . : National Park System, National Wildlife Refuge System, National System of Trails, National Wilderness Preservation System, National Wild and Scenic Rivers System, National Recreation Areas, land acquired with money derived from the Land and Water Conservation Fund, National Forests, and Federal lands in incorporated cities, towns, and villages.

2. Federal lands that are within rights-of-way or easements or within surface leases for residential, commercial, industrial, or other public purposes, on federally owned surface.

3. Federal lands . . . within 100 feet of the outside line of the right-of-way of a public road or within 100 feet of a cemetery, or within 300 feet of any public building, school, church, community or institutional building or public park or within 300 feet of an occupied dwelling.

4. Federal lands designated as wilderness study areas . . . while under review by the Administration and the Congress for possible wilderness designation.

5. Scenic Federal lands designated by visual resource management analysis as Class I (an area of outstanding scenic quality or high visual sensitivity).

6. Federal lands under permit by the surface management agency, and being used for scientific studies involving food or fiber production, national resources, or technology demonstrations and experiments... except where mining could be conducted in such a way as to enhance or not jeopardize the purposes of the study.

7. All districts, sites, buildings, structures, and objects of historic, architectural, archaeological, or cultural significance on Federal lands which are included in or eligible for inclusion in the National Register of Historic Places, and an appropriate buffer zone around the outside boundary of the designated property.

8. Federal lands designated as natural areas or as National Natural Landmarks.

9. Federally designated critical habitat for threatened or endangered plant and animal species, and habitat for Federal threatened or endangered species which is determined by the Fish and Wildlife Service and the surface management agency to be of essential value and where the presence of threatened or endangered species has been scientifically documented.

10. Federal lands containing habitat determined to be critical or essential for plant or animal species listed by a state pursuant to state law as endangered or threatened.

11. A bald or golden eagle nest or site on Federal lands that is determined to be active and an appropriate buffer zone of land around the nest site.

12. Bald and golden eagle roost and concentration areas on Federal lands used during migration and wintering.

13. Federal lands containing a falcon (excluding kestrel) cliff nesting site with an active nest and a buffer zone of Federal land around the nest site.

14. Federal lands which are high priority habitat for migratory bird species of high Federal interest on a regional or national basis, as determined jointly by the surface management agency and the Fish and Wildlife Service.

15. Federal lands which the surface management agency and the state jointly agree are fish and wildlife habitat for resident species of high interest to the state and which are essential for maintaining these priority wildlife species.

16. Federal lands in riverine, coastal and special floodplains (100-year recurrence interval).

17. Federal lands which have been committed by the surface management agency to use as municipal watersheds.

18. Federal lands with National Resource Waters, as identified by states in their water quality management plans.

19. Federal lands identified by the surface management agency, in consultation with the state in which they are located, as alluvial valley floors... where mining would interrupt, discontinue, or preclude farming.

20. Federal lands in a state to which is applicable a criterion (i) proposed by that state, and (ii) adopted by rulemaking by the Secretary (of the Interior).

Oil Shale

Lands containing oil shale are leased only under provisions of the 1980 Department of the Interior Prototype Oil Shale Leasing Program.

Restrictions on BLM Land

Most BLM land is open to mineral exploration and development under multiple-use management principles, but significant portions are unavailable or are restricted.

About 801,000 acres of BLM wilderness study areas (table E-4) constitute the largest category of BLM land regarded as unavailable or severely restricted to locatable and leasable mineral activities. On the plates, these areas are shown as unavailable or severely restricted by management decision from location or mineral leasing under present policy because these areas are managed under strict control to maintain wilderness character. Proposed wild and scenic river corridors, likewise, are regarded as unavailable.

The BLM inventory of formally withdrawn areas (39) indicates the amount of BLM land that is legally unavailable for mineral location and leasing. Formal review of these withdrawals, required by FLPMA, is under way. Unless the withdrawal can be justified, it will be revoked and the land restored to entry.

Oil shale withdrawals made during the 1930's are the second largest area of unavailable or severely restricted BLM land. These areas are closed to location and to leasing for oil shale and sodium, but are available for other leasable minerals.

Most other withdrawals on BLM land are small and are not shown on the plates because they are each less than 1 mi². Included are Federal agency protective withdrawals and Pickett Act, Recreation and Public Purposes Act, Small Tract Act, and other withdrawals. Numerous public water reserves also are not shown because of their small size; these are withdrawn from location for nonmetalliferous minerals only. Powersite withdrawals, including powersite reserves, classifications, and projects, are not shown because the areas are not regarded as severely restricted. Reclamation withdrawals are discussed under the later Bureau of Reclamation (BOR) section.

In 1983, BLM made an inventory (40) of "de facto" withdrawals in Colorado, including land segregated by application and notices of realty action, BLM-acquired lands not opened, and BLM land classifications. One large segregation is for the Department of Defense (DOD) Pinon Canyon site; however, most of the remaining segregations are too small to be shown on the plates.

For each of its resource areas, BLM has written environmental analyses (42) that assess suitability of BLM land in Colorado for oil and gas leasing. Management decisions based on the analyses result in 2,958,000 acres being subject to seasonal restrictions on surface occupancy and 846,000 acres being subject to yearlong no-surface-occupancy or no-leasing restrictions. The seasonal restrictions are regarded as a slight to moderate restriction for oil and gas leasing and are not shown on the plates; the areas of yearlong no-surface-occupancy and no-leasing are shown.

NATIONAL PARK SERVICE

NPS manages 597,622 acres in 11 units in Colorado. Table E-5 lists acreage by unit for NPS land in the State.

Table E-4.—Bureau of Land Management wilderness study areas and instant study areas in Colorado

District and name of area	BLM number	acres
WILDERNESS STUDY AREAS		
Canon City District:		
Beaver Creek	CO-050-018	26,150
Black Canyon	CO-050-131	2,300
Browns Canyon	CO-050-002	6,614
Lower Grape Creek	CO-050-014	10,630
McIntyre Hills	CO-050-013	16,060
Papa Keel	CO-050-137	1,020
Sand Castle	CO-050-136	1,644
San Luis Hills	CO-050-141	10,240
South Piney Creek	CO-050-132B	870
Upper Grape Creek	CO-050-017	9,840
Zapata Creek	CO-050-139B	720
Subtotal		86,086
Craig District:		
Adjacent to Dinosaur National Monument	CO-010-224	4,340
Do	CO-010-224A	1,320
Do	CO-010-229	4,880
Do	CO-010-228	5,200
Do	CO-010-229D	6,900
Do	CO-010-007A	9,932
Black Mountain	CO-010-001	12,297
Bull Canyon	CO-010-208	14,587
Cold Springs West	CO-010-230	14,081
Cross Mountain	CO-010-214	35,380
Diamond Breaks	CO-010-048	17,740
Oil Spring Mountain	CO-010-003	13,514
Skull Creek	CO-010-155	8,250
Troublesome	CO-010-002	13,274
Willow Creek	CO-010-007C	12,274
Windy Gulch		
Subtotal		173,969
Grand Junction District:		
Black Ridge Canyons	CO-070-113	18,150
Black Ridge Canyons West	CO-070-113A	54,290
Bull Gulch	CO-070-430	14,364
Castle Peak	CO-070-433	11,940
Demaree Canyon	CO-070-099	21,050
Dominguez Canyon	CO-070-150	75,800
Eagle Mountain	CO-070-392	330
Hack Lake	CO-070-425	3,360
Little Bookcliffs Wildhorse Area	CO-070-066	26,525
Sewmup Mesa	CO-070-176	19,140
The Palisade	CO-070-132	26,050
Subtotal		270,999
Montrose District:		
Adobe Badlands	CO-030-370B	10,560
American Flats	CO-030-217	4,710
Cahone Canyon	CO-030-265D	8,385
Camel Back	CO-030-353	10,900
Cross Canyon	CO-030-265	9,440
Dolores River Canyon	CO-030-290	25,550
Gunnison Gorge	CO-030-388	20,240
Handies Peak	CO-030-241	18,260
McKenna Peak	CO-030-286	21,900
Manitou Mountain	CO-030-251	7,280
Needle Creek	CO-030-229B	4,540
Red Cloud Peak	CO-030-208	38,400
Squaw/Papoose Canyons	CO-030-265A	11,260
Tabogauche Creek	CO-030-300	7,270
Weber Mountain	CO-030-251	6,200
Weminuche Contiguous	CO-030-238B	1,980
West Needles Contiguous	CO-030-229A	5,780
Whitehead Gulch	CO-030-230B	5,560
Subtotal		218,215
Total wilderness study areas		749,271
INSTANT STUDY AREAS¹		
Canon City District: High Mesa	NAP	680
Craig District: North Sand Dunes	NAP	791
Montrose District:		
Needle Rock	NAP	80
Powderhorn ²	NAP	50,140
Rare Lizard and Snake	NAP	443
Total instant study areas		52,134
Grand total		801,405

NAP: Not applicable.

¹Previously designated natural or primitive area, may be withdrawn from mining or mineral leasing laws.²Acres include 9,660 acres of land contiguous to primitive area.

Source: BLM Wilderness Status Map, Sept. 1983; and Federal Register. BLM List of Wilderness Study Areas and Study Schedule. V. 48, No. 249, Dec. 27, 1983, pp. 57060-57065.

Table E-5.—National Park Service units in Colorado, net acres

Bent's Old Fort Historic Site	800
Black Canyon of the Gunnison	13,672
Colorado National Monument	29,454
Curecanti National Recreation Area	42,114
Dinosaur National Monument	156,536
Florissant Fossil Beds National Monument	5,988
Great Sand Dunes National Monument	36,982
Hovenweep National Monument	345
Mesa Verde National Park	52,085
Rocky Mountain National Park	266,942
Yucca National Monument	10
Total	597,622

Source: NPS.

In general, all NPS land is withdrawn from mineral location and mineral leasing by the NPS Organic Act of 1916 and the enabling act that established an area. All units in Colorado, except the Curecanti NRA, are legally unavailable for mineral location and leasing. Previous valid existing mineral rights within these areas were not abrogated by the enabling acts, but mineral activity was strictly limited by the Mining in the National Parks Act of 1976 and NPS regulations.

Curecanti NRA is legally withdrawn from location, but it is open, at least in theory, to mineral leasing because the underlying reclamation withdrawal did not specifically segregate the land from leasing laws. However, the policy of NPS, which is now responsible for its management, is to reject lease applications while awaiting formal designation of the area as a unit of NPS.³ Accordingly, Curecanti NRA is presently considered unavailable or severely restricted for mineral leasing owing to management decision.

DEPARTMENT OF DEFENSE

More than 491,000 acres of land in Colorado are administered by DOD. Location and size of principal military installations are shown in table E-6. It is DOD policy that,

¹Keith Miller, BLM Canon City, CO. Private communication, Sept. 1983.

Table E-6.—Federal land administered by the Department of Defense in Colorado

Administering agency and name of facility	Location	Acres
Army Corps of Engineers: Civil works projects ¹	Various places	38,260
Department of the Air Force:		
Air Force Academy	Colorado Springs	18,328
Buckley Air Force Base	Aurora	2,365
Cheyenne Mountain Complex	Colorado Springs	591
La Junta Radar Bomb Score Site	La Junta	6
Lamar Communications Facility	Lamar	95
Lowry Air Force Base	Denver	5,781
Marin Missile Test Site	Littleton	464
Peterson Air Force Base	Colorado Springs	1,796
Department of the Army:		
Fitzsimons Army Medical Center	Aurora	577
Fort Carson	Colorado Springs	137,391
Pinon Canyon Site ²	Las Animas County	244,000
Pueblo Army Depot	Pueblo	24,201
Rocky Mountain Arsenal	Commerce City	17,238
Total		491,113

¹BLM (38, table 9).²Robert Middlemiss, reality specialist, Fort Carson Army Base. Private communication, Sept. 9, 1983.

Source: DOD List of All Military Installations (Excluding Reserve Centers and Minor Properties). 1981 (FY 1980 data), p. 12.

"... DOD lands shall be made available for mineral exploration and extraction to the maximum extent possible consistent with military operations, national defense activities, and Army civil works activities." (32 CFR 235). This directive, however, applies only to leasable minerals. These lands, which include those administered by the Army Corps of Engineers, are subject to the operation of applicable public land mining and mineral leasing laws, except where the Secretary of Defense, after consultation with the Secretary of the Interior, determines that such disposition or exploration is inconsistent with the military use of the lands so withdrawn or reserved (43 U.S.C., 1970, §158).

Locatable Minerals

Because exploration for the development of locatable minerals on public domain land reserved for military or civil works purposes could lead to a patent under the General Mining Law of 1872, these activities are considered to be incompatible with the current use of the land. Such land, even where not formally segregated from the mining laws, is therefore closed to entry for all practical purposes.³ Proposals to formally withdraw more than 144,000 acres of federally owned minerals on DOD-administered lands were made by BLM in 1983. Accordingly, most DOD-administered land, both civil works and military, is closed to location because it is formally withdrawn, part of a pending action, or closed by management policy. In rare cases, the Department of the Interior (DOI) may determine that locatable minerals might be present in sufficient quantities so that mining these minerals may be considered the dominant use of the land. Should this occur, consideration could be given by the military for determining the land as excess.⁴

Mineral Leasing

Lease applications for DOD land are evaluated on a case-by-case basis by the appropriate military department of DOD and DOI (32 CFR 235). Leases may not be issued unless the military department can consent to exploration and, ultimately, to allow drilling or other forms of mineral extraction. Availability of DOD land for lease is subject to certain conditions and stipulations; severe restrictions may be imposed by DOD and DOI on those applications that are approved.⁵ Although such lands are not formally closed to leasing, they are considered in this study to be unavailable or severely restricted by management decision, owing to the requirement that their use be compatible with the mission of DOD.

BUREAU OF RECLAMATION

BOR manages 243,000 acres in 31 projects within Colorado (table E-7). In general, BOR lands withdrawn from public domain (161,631 acres) are legally closed to mineral location and entry under the general mining laws. After a project is completed, project withdrawals are reviewed and those on land no longer essential to the project are revoked. Almost all BOR land, public domain and acquired land, is open to oil and gas leasing. BOR advises BLM what, if any, stipulations must be contained in the lease terms to protect the project and the surface resources.

³Department of the Army Directive and Regulations, Feb. 26, 1982.

⁴Department of the Army, 1982.

⁵Department of the Army, 1982.

Table E-7.—Land managed by the Bureau of Reclamation in Colorado, acres¹

Project or unit name	Acquired land	Withdrawn public land	Total
Reclamation projects:			
Aniwas-La Plata	0	2,834	2,834
Colbran	1,907	813	2,720
Colorado-Big Thompson	8,347	241	8,588
Dolores	11,278	5,083	16,371
Florida	132	29	161
Fruitgrowers Dam	446	120	566
Fruitland Mesa	0	22,555	22,555
Fryingpan-Arkansas	21,938	6,667	28,605
Grand Valley	26	3,407	3,433
Juniper	0	36,696	36,696
Leadville Mine Drainage	8	195	203
Mancos	554	280	834
Paonia	535	1,448	1,983
Pine River	3,142	555	3,697
San Juan-Chama	79	0	79
San Luis Valley	68	2,400	2,468
Savery-Pot Hook	0	10,202	10,202
Silt	1,019	515	1,534
Smith Fork	651	120	771
Uncompahgre	1,185	1,527	2,712
Colorado River Storage:			
Curecanti Unit ²	10,993	31,368	42,361
Nevajo Unit	5,475	0	5,475
West Divide	0	740	740
Whitewater Unit	0	28,144	28,144
Pick-Sloan Missouri Basin Program:			
Armel Unit	7,228	1	7,229
Narrows Unit	2,326	328	2,654
Upper South Platte	0	1,283	1,283
Rio Grande: Closed basin, San Luis Valley	320	0	320
Other land	3,314	2,050	5,364
Total	80,971	161,631	242,602

¹Excludes public and private easement land.

²Transfer to NPS pending.

Source: BOR.

DEPARTMENT OF ENERGY

DOE administers 84,803 acres in Colorado. Naval Oil Shale Reserves 1 and 3, totaling 54,993 acres, are in Garfield County. Both are legally closed to mineral location and mineral leasing. Atomic energy withdrawals, formerly managed by the Atomic Energy Commission, are in Mesa, Montrose, Rio Blanco, and San Miguel Counties. All but 1,240 of the 29,426 acres of these withdrawals is open to mineral leasing, but none is available for location (Public Land Order (PLO) 494, PLO 565, PLO 779, and PLO 5344). About 6,500 acres in Jefferson County is occupied by the Rocky Flats Plant; this land is not legally withdrawn from location, but the sensitive nature of the work performed at the facility is not compatible with mineral exploration or development. The site also is closed to surface occupancy for mineral leasing.⁶ Several tracts located throughout the State are managed as powersites by the Western Area Power Administration. The sites aggregate 446 acres and range from less than 1 to more than 40 acres in area. Through management policy, they are open to leasing with no surface occupancy and closed to location.⁷

FISH AND WILDLIFE SERVICE

FWS manages four wildlife refuges and two fish hatcheries totaling 58,776 acres in Colorado. In addition, 1,153

⁶Pat Corrier, DOE. Private communication, Sept. 1982.

⁷Bobbie Bond, DOE. Private communication, Sept. 1982.

Table E-8.—Land managed by the Fish and Wildlife Service in Colorado

Project purpose and name	County	Acres
Wildlife refuges:		
Alamosa	Alamosa	10,357
Aspenho ¹	Jackson	17,553
Browns Park	Moffat	13,375
Monte Vista	Rio Grande	14,189
Fish hatcheries:		
Hotchkiss	Delta	139
Leadville ²	Lake	3,053
Under State management:		
Hot Sulphur	Grand	1,115
Mesa Reservoir	Mesa	38
Total		59,929

¹PLO 6531 (May 1, 1984) added 3,072 acres.

²Includes 2,560 acres within Mount Massive Wilderness.

Source: FWS Annual Report of Lands Under Control of the U.S. Fish and Wildlife Service, as of Sept. 30, 1982. Pp. 3-4, 14, 17, 20.

acres of FWS land are coordination areas managed by the State. Table E-8 lists acreages of FWS land in Colorado.

Except for 635 acres of the 1,115 acres under State management in the Hot Sulphur area, FWS land is closed to mineral location.^a Most FWS land is acquired, and the Federal locatable minerals are unavailable by regulation (50 CFR 27.64). The public domain land is withdrawn from operation of the mining laws.

FWS land is also closed by regulation to oil and gas leasing (43 CFR 3101.3-3), except where drainage is occurring, and to coal leasing (43 CFR 3400.2). All lands are open to seismic methods of exploration for oil and gas. Oil and gas development permits would be reviewed by BLM for drainage suitability, followed by FWS management review on a case-by-case basis for compatibility with land use pursuant to 50 CFR 32 and 2921.^b Specific restrictions would

be imposed upon operations of the lessee when a permit is issued.¹⁰

OTHER FEDERAL AGENCIES

Twelve Federal agencies administer the remaining 22,297 acres of federally owned land in the State of Colorado. The Central Plains Experimental Range, managed by the Agricultural Research Service, occupies 14,639 acres in the Pawnee National Grassland. Most of the other tracts administered by these agencies are too small to be shown on the plates that accompany this report. In general, the tracts are dedicated to a specific use. Many are legally closed to mineral location, and some are legally closed to mineral leasing. The remainder are considered in this report to be closed to location and mineral leasing by management decision. Table E-9 lists these agencies and the acreage they manage.

¹⁰Marvin Planert, FWS, Denver, CO. Private communication, Aug. 1983.

Table E-9.—Other Federal land-managing agencies in Colorado, acres

Department of Agriculture: Agricultural Research Service	114,706
Department of Commerce:	
National Bureau of Standards	586
National Oceanic and Atmospheric Administration	35
Office of Telecommunications ²	2,473
Department of the Interior: Bureau of Indian Affairs	317
Department of Justice: Bureau of Prisons	295
Department of Transportation: Federal Aviation Administration ..	945
Department of the Treasury: Bureau of the Mint	2
General Services Administration	1,196
National Science Foundation	526
United States Postal Service	79
Veterans Administration	1,137
Total	22,297

¹Includes 14,639-acre Central Plains Experimental Range and 67 additional acres.

²Now National Telecommunications and Information Administration.

Source: BLM (38).

^aJuris Eglite, FWS, Denver, CO. Private communication, Aug. 1983.

^bJuris Eglite, FWS, Denver, CO. Private communication, Aug. 1983.

APPENDIX F.—PURPOSES OF RESTRICTIONS

Mineral exploration and development on Federal land is restricted for many reasons. In general, the land is restricted because it has been dedicated to uses that would not be compatible with mineral activity or because such activity would not be compatible with another resource value in the land.

PROTECTION OF WILD AND NATURAL AREAS

The largest category of restricted Federal land in Colorado is for the protection of wild and natural areas. Designated wilderness areas, wilderness study areas (including instant study areas and further planning areas), components of the Wild and Scenic River System, and natural areas are included in this category. These areas, managed by the Forest Service (FS), Bureau of Land Management (BLM), National Park Service (NPS), or the Fish and Wildlife Service (FWS), aggregate 4,357,085 acres (table F-1).

Effective January 1, 1984, the Wilderness Act of 1964 formally closed designated wilderness areas to mining and mineral leasing activities, subject to valid existing rights. Accordingly, these areas are considered to be legally unavailable in this study.

FS evaluated national forest roadless areas under the Roadless Area Review and Evaluation (RARE and RARE II) programs. As a result, wilderness study areas and further planning areas have been identified. These areas are managed under regulations designed to preserve their wilderness character until Congress decides whether or not to place them into the National Wilderness Preservation System (NWPS). These areas are regarded as severely restricted by management decision to mineral exploration and development; current policy is not to issue leases in such areas.

Section 603 of the Federal Land Policy and Management Act of 1976 (FLPMA) directed BLM to conduct a wilderness review program. As a result of its inventory, BLM identified wilderness study areas and instant study areas in Colorado. During the review process, these areas are managed under regulations intended to maintain their wilderness values. Accordingly, these areas also are regarded as severely restricted by management practice to activity under the mining and mineral leasing laws.

The Wild and Scenic Rivers Act of 1968 allows for protection of certain rivers and adjacent land within 0.25 mile of each bank. Colorado currently has no designated wild and scenic rivers, but 782 miles of rivers in the State have been proposed for designation. Proposed river segments, out-

side otherwise restricted areas, are managed to preserve their wild and scenic character, and these areas are considered to be severely restricted by management practice to activity under the mining and mineral leasing laws.

FS and BLM have also designated smaller areas as outstanding or research natural areas. These areas are set aside to protect their exceptional scenic or scientific resources, threatened or endangered species, or rare biological or geological features, for preservation in their natural state and for research purposes. Most of these areas are withdrawn from operation of the mining laws and are regarded as unavailable or severely restricted for mineral leasing. Some have been set aside primarily for wilderness values; however, others are within the scope of succeeding sections.

PROTECTION OF SCENIC, HISTORIC, AND RECREATION VALUES

Areas in this category include national parks and monuments, national recreation areas, and historic and archaeological sites.

All national parks and monuments in Colorado are closed by law to activity under both the mining and mineral leasing laws. These areas are listed under NPS, the managing agency, in appendix E.

National recreation areas (NRA), including two in Colorado, have been established generally on land previously or concurrently withdrawn for reclamation or other water resource development purposes. Availability of these areas either for mineral leasing or for location depends upon provisions specified in the particular withdrawal order and the enabling law or executive action. In Colorado, the Curecanti NRA (administered jointly by NPS and the Bureau of Reclamation (BOR)) is legally closed to mining activity because of the earlier reclamation withdrawal and is considered severely restricted to mineral leasing because of NPS policy toward leasing on its units. Except for tracts that are legally withdrawn or for areas specifically managed to preclude leasing, the Arapaho NRA (administered by the FS) is open to mining and mineral leasing activities.

The Antiquities Act of 1906 and several succeeding statutes protect public land determined to be of historic or archaeological value. Tracts of public land determined to have such value are generally small and often are formally withdrawn from mineral location, but usually not from leasing. All other tracts of Federal land may be subject to surveys, salvage, or withdrawal whenever historic or archaeological value is found. Laws require surveys prior to

Table F-1.—Colorado wilderness-type areas, acres

Agency ¹	Designated wildernesses ²	Wilderness study areas ³	Proposed wild and scenic river corridors	Total
Forest Service	2,585,682	661,510	(4)	3,247,192
Bureau of Land Management	0	801,405	(4)	801,405
National Park Service	55,687	0	(4)	55,687
Fish and Wildlife Service	2,580	0	(4)	2,580
Undesignated	0	0	250,240	250,240
Total	2,643,930	1,462,915	250,240	4,357,084

¹Detailed list of areas given under each agency (see appendix E).

²Legally unavailable to mineral location and leasing.

³Severely restricted by management to mining and mineral leasing; includes FS further planning areas and BLM instant study areas.

⁴Agency not designated, includes BLM and FS land; part is legally unavailable and part is severely restricted by management.

mineral activities on Federal land, and the land managing agency may effect emergency withdrawals if valuable resources needing protection are found. Only formal withdrawals are shown on the plates in this study, but the acreage that might be affected by the Antiquities Act and succeeding statutes could be substantially larger.

MILITARY LANDS

Most land reserved for military purposes is technically open for mineral exploration and development. In Colorado, virtually all military land is acquired Federal land, and all minerals are subject to leasing, except where the Secretary of Defense, after consultation with the Secretary of the Interior, determines that such disposition is inconsistent with the military use of the land. Small tracts of public domain land in military reservations at Ft. Carson and at Pinon Canyon are formally withdrawn under the mining laws, and a larger buffer zone of national forest adjacent to the Air Force Academy is withdrawn from the mining and mineral leasing laws. Remaining public domain land within the Ft. Carson and Pinon Canyon reservations were proposed for withdrawal from mineral location in 1983. All other land administered by the Department of Defense (DOD) is regarded in this report as unavailable or severely restricted by management decision for leasing because the Secretary of Defense has generally held that land reserved for military purposes should be closed. Appendix E describes agency policy and lists DOD land in Colorado.

PROTECTION OF FISH AND WILDLIFE

Colorado has four national wildlife refuges and two national fish hatcheries administered by FWS. Public domain land in these areas is formally withdrawn and unavailable under the mining laws. Acquired land also is regarded in this study to be unavailable by management decision for mineral leasing; see appendix E for details.

The Endangered Species Act of 1973 directs all Federal agencies to ensure that their actions do not harm threatened or endangered species or destroy or modify "critical habitat" of such species. The Alamosa and Monte Vista National Wildlife Refuges in south-central Colorado are designated critical habitat for the whooping crane (50 CFR 17.95). No other formally designated critical habitat has yet been identified in Colorado. Both FS and BLM, however, have identified areas of wildlife habitat where mineral leasing would be denied or be subject to seasonal or yearlong no-surface-occupancy restrictions; presumably, operating plans for mineral activity under the mining laws and regulations would be similarly restricted. Areas subject to yearlong no-surface-occupancy are judged severely restricted and are shown on the plates, but seasonal no-surface-occupancy is regarded as a slight to moderate restriction and subject areas are not shown. An in-house tabulation of the areas under no-surface-occupancy indicates that about 1.72 million acres are restricted yearlong and about 4.28 million are restricted seasonally.

BLM also has identified areas of critical environmental concern (ACEC), which require special management attention to protect fish and wildlife or other resource values, where mineral activities would be allowed subject to restrictions depending upon the situation. Unless the ACEC is

otherwise withdrawn, these areas are regarded in this study as slightly or moderately restricted by management decision.

CONSERVATION OF MINERALS

Large areas in Colorado were withdrawn from appropriation under the mining laws early in the 20th century to protect public lands containing valuable deposits of coal, petroleum, and oil shale, until legislation was passed to provide for orderly development of such resources. More recently, areas containing geothermal resources also were similarly withdrawn. Additional lands withdrawn for atomic energy resources are discussed in the next section under energy development.

Lands containing oil shale were withdrawn in 1930 by Executive Order 5327 and Public Land Orders (PLO) 4522 and 5029. As modified by later executive decisions, the current status of land subject to the withdrawal order is—open to leasing for oil and gas; closed to location under the general mining laws and to sodium leasing, except where such leasing would not affect the oil shale values; and open to oil shale leasing at the discretion of the Secretary of the Interior under provision of the 1980 Prototype Oil Shale Leasing Program. A substantial part of the oil shale withdrawal was revoked on May 16, 1983, by PLO 6387. Lands still withdrawn for oil shale are regarded as unavailable to locatable mineral activity.

The two naval oil shale reserves in Colorado are closed to both the mining and the mineral leasing laws by withdrawals.

Coal withdrawals are segregated only from mineral entry for nonmetalliferous minerals. Owing to the lack of significant impact of these withdrawals on the selected metallic and nonmetallic minerals shown on plate 1, coal withdrawals are considered only a slight restriction and are not included in this study.

ENERGY DEVELOPMENT

Similar, in part, to withdrawals for mineral conservation are lands withdrawn for the old Atomic Energy Commission for atomic energy purposes. These lands now are administered by the Department of Energy (DOE); specific tracts are withdrawn from the mining and, less frequently, the mineral leasing laws. Pursuant to the Atomic Energy Act of 1954 and regulations (10 CFR 760.1), however, DOE may issue, at its discretion, permits and leases for uranium on these withdrawn lands and on other public lands withdrawn from location. Thus, restricted areas shown on plate 2 may still be available for uranium leasing should DOE decide to issue leases.

Although originally withdrawn from disposition by the Federal Water Power Act of 1920, powersite withdrawals and classifications not covered by a permit or license were opened by the Mining Claims Rights Restoration Act in 1955 to the mining and mineral leasing laws. At any time, however, power development can disrupt or stop mineral activities without compensation. In an individual case, the impact could be severe, but as a class, powersite withdrawals are regarded as a moderate restriction to mineral activity and are not shown on the plates.

SURFACE OCCUPANCY AND RESOURCE DEVELOPMENT

This category includes a wide variety of withdrawals. Although they are quite numerous, most are small and cannot be shown on the plates.

Surface occupancy withdrawals in Colorado are for such diverse purpose as administrative sites, hospitals and cemeteries, recreation sites, roadside zones, test and communication facilities, and other agency purposes. In general, land withdrawn for such purposes is unavailable under the mining laws but open to mineral leasing at the discretion of the agency. Most of this land is under the jurisdiction of FS or BLM, but other agencies and purposes also were noted in the inventory (39). In addition, some Federal land is withdrawn for non-Federal uses; e.g., land withdrawn under the Recreation and Public Purpose Act of 1926 for local government purposes.

Surface resource withdrawals include land withdrawn for public water supply, flood control, and irrigation projects. Water supply withdrawals have been established for certain municipalities by law and are unavailable for any

mineral activity. A second type, known as public water reserves, was established by Public Water Reserve 107 in 1926. Public water reserves include numerous, small withdrawals on public lands around springs or waterholes, which are closed only to nonmetalliferous minerals; thus, they represent no restriction for leasable minerals or for most of the selected locatable minerals and are not shown on the plates.

Land withdrawn or restricted for flood control or irrigation projects is administered by BOR or the Army Corps of Engineers. Although Corps of Engineers land is technically open to mineral development, leasing would be subject to stipulations placing mineral activity subordinate to project purposes; these areas are considered unavailable or severely restricted in this study. Reclamation withdrawals generally are closed under the mining laws, but they are open to mineral leasing with stipulations to protect the dominant reclamation purpose.

Federal reserved minerals in stockraising and agricultural homestead lands are not shown on the maps and are outside the scope of this study.

